5.4 INDICATOR ~~CHEMICALS~~ CONTAMINANTS IN SURFACE WATER

This section summarizes the surface water data ~~for the LWG rounds of~~ collected during the RI investigation. These data include those collected between November 2004 and March 2007. ~~-~~ The surface water study was designed to characterize surface water ~~chemical~~contaminant concentrations and flow conditions of the river during three different flow regimes: ~~-~~low river flow (low ~~-~~flow; <50,000 cfs), high river flow (high ~~-~~flow; >50,000 cfs), and storm water-influenced flow (sampling during active runoff in the Study Area). The threshold discharge rate of 50,000 cfs was selected because it is the river discharge at which significant transport of streambed sediment begins (Willamette Basin Task Force 1969). The geographic locations of all ~~Round 2A and 3A~~ surface water sampling locations are presented on Map 2.1-18~~2~~ ~~4~~.

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The discussion of the ICs addressed in this section focuses primarily on the following elements:

- A description of the data set for each contaminant;~~, including frequency of detection and~~
- The relationship of contaminant concentration with respect to flow rate; ~~concentration range~~
- ~~The relationship of chemical concentration with respect to location, flow rate;~~
- ~~The relationship of chemical concentration with respect to dissolved and particulate fractions; and, association with suspended solids, and associated organic carbon~~
- The sampling locations and event types with elevated contaminant concentrations compared to ambient water quality criteria (AWQC); and
- Locations with the highest contaminant concentrations.~~.~~

The following subsections present tables and other graphical formats to support discussion and evaluation of the in-river distribution of ICs. Additional tabular and graphical summaries of the other key COCs in surface water are included in Appendix D3. Finally, surface water sampling results are compared to various water screening values in Appendix D3.3,~~:~~ where contaminants that exceed the screening values are identified in the evaluation.

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The final subsection in this discussion presents a site-specific evaluation of hydrophobic contaminants using four contaminants:~~,~~ PCBs, Dioxin/Furans, PAHs, and DDx. This discussion presents ~~and any apparent spatial or temporal gradients among the data set~~ the relationship of ~~chemical~~contaminant concentration with respect to dissolved and particulate fractions and ~~association~~relationship with suspended solids~~,~~ and associated organic carbon.

- An evaluation of contaminant concentrations found in the Study Area reach compared to concentrations found at locations outside of the Study Areain other river reaches

Maps 5.3-1a–c present the surface water sampling locations symbolized according to sampling method. The following subsections present tables hydrographs, histograms, scatter plots, and line plots, and stacked bar graphsother graphical formats to support discussion and evaluation of the nature and extentin river distribution of selected ICs. Additional tabular and graphical summaries of the other key COCs in surface water data set are included in Appendix D3. Finally, surface water sampling results are compared to various water screening values in Appendix D3.3; ccontaminants that exceed one or morethe screening values are identified in the evaluation.

The surface water chemistry distributions and supporting information are depicted in several graphical formats: hydrographs and hyetographs of sampling events, discharge rates, and precipitation events, and histograms of sample concentrations for all sampling events for the ICs, along with line plots, stacked bar charts, and scatter plots for the ICs.

Hydrographs and Hyetographs: The hydrographs show the average discharge rates during the Round 2A and 3Aeach surface water sampling events and the hyetographs show precipitation events and amounts to provide perspective on the timing of the Round 2A and 3A sampling events and the specific conditions prior to, during, and after each event. These are provided as Figures 5.4-1 through 5.4-4.

Histograms: The histograms provide a graphical summary of the distribution of chemicalsICs for all the surface water sampling events. For each analyte, data are presented in two types of histograms: data sorted by flow event type (high -flow, low -flow, and stormwaterstorm water-influenced flow) and data sorted by location in the river channel (west and east channel and transect locations). For the XAD samples (units in pg/L), the individual data points are composed of shaded stacked bars to distinguish between the XAD column and XAD filter samples. The bars are color-coded to distinguish between the single -point samples (blue) and the transect samples (orange). The non-detected samples are displayed with a hatch pattern or open bar. The same scheme is used for the peristaltic samples (units in µg/L), with shaded stacked bars for total and dissolved fractions and blue and orange colors for the single -point and transect samples. In Round 2, stations were analyzed for PAHs in both the XAD and peristaltic samples; the histograms for the peristaltic samples only display samples where PAHs were not analyzed in the XAD sample. Multnomah Channel and Swan Island Lagoon are indicated by "MC" and "SIL", respectively, on the histograms.

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Line Plots: The line plots present the concentrations of the bounding ICs for each flow type (high -flow, low -flow, stormwaterstorm water-influenced) at the transect stations for all surface water sampling events. The squares, diamonds, and triangles represent the data points. Prior to generating the plots, data were averaged so that only one value per transect per sampling event was used. NB and NS total (dissolved plus particulate)

concentrations were averaged for samples from stations W027 (Multnomah Channel), W005 (RM 4), W011 (RM 6.3), and W024 (RM 16) and east, west, and mid-channel total concentrations were averaged for stations W025 (RM 2) and W023 (RM 11), where applicable. The data for the 2007 high -flow event is displayed in two colors because this event was completed in two phases with a stand -down period between high -flow conditions.

Scatter Plots: Scatter-plot presentations of the surface water data show concentrations of the ICs by river mile. The symbols on the scatter plots distinguish between flow types (high flow, low flow, storm water-influenced flow) and single-point and transect samples. The evaluation of hydrophobic ICs presents IC relationships with flow, TSS, and organic carbon. Particulate versus dissolved concentrations are also presented for detailed evaluation of the results. The symbols on the scatter plots distinguish between flow types (high flow, low flow, storm water-influenced flow) and sign point and transect samples.

5.4.1 Surface Water Data Set

~~The LWG conducted two rounds of surface water investigation for this RI.~~ The Round 2A and 3A surface water sampling programs consisted of seven field collection events that occurred between November 2004 and March 2007. ~~The surface water study was designed to characterize surface water chemical concentrations and flow conditions of the river during three different flow regimes: low river flow (low-flow; <50,000 cfs), high river flow (high-flow; >50,000 cfs), and stormwater-influenced flow (sampling during active runoff in the Study Area). The threshold discharge rate of 50,000 cfs was selected because it is the river discharge at which significant transport of streambed sediment begins (Willamette Basin Task Force 1969).~~ The seven events are listed below:

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- November 2004 (Round 2A, low -flow)
- March 2005 (Round 2A, low -flow)
- July 2005 (Round 2A, low -flow)
- January 2006 (Round 3A, high -flow)
- September 2006 (Round 3A, low- flow)
- November 2006 (Round 3A, storm water-influenced flow)
- January-March 2007 (Round 3A, high -flow[1]).

Other studies included in this evaluation are:

[1] The January 2007 high-flow event was cancelled after two days of sampling due to unexpected change in flow conditions. Sampling recommenced on February 21, 2007 once high-flow conditions (>50,000 cfs) were once again observed and continued through March 10, 2007.

- Siltronic – ~~In~~ May and June 2005 ~~during low flow river conditions, Siltronic collected 22 near-bottom surface water samples at stations located from RM 6.4 to RM 6.5. Samples were generally collocated with TZW sampling locations. Samples were collected with a peristaltic pump and analyzed for conventional parameters, VOCs, and SVOCs. The Supplemental Investigation Report (~~MFA 2005b, low flow~~) presents additional information on the Siltronic surface water samples~~).

- NW Natural – ~~Surface water grab samples were collected at 20 locations near the Gasco site from RM 5.9 to RM 6.7. At each location, near-surface, mid-depth, and near-bottom samples were collected in~~ October 2007~~, in low-flow conditions, during three tidal periods: ebb, slack high, and slack low. A total of 180 surface water samples were tested for conventional parameters, cyanide, and select metals. The Gasco surface water samples are discussed in more detail in the Offshore Groundwater Field Sampling Approach (~~Anchor 2006b~~) and the Offshore Investigation Report (~~Anchor 2008b, low flow~~).

- City of Portland – ~~The City of Portland collected surface water TSS data between~~ February 5, 1992 and March 15, 2006 (Sanders 2006, TSS). ~~The surface water samples were collected at a 10-ft depth from the east, middle, and west locations along transects at RM 1.1, 6.8, 8.8, 12.7, 17.9, and 20, and were composited by transect.~~

Peristaltic and XAD (column and filter) samples were collected during all sampling events, but not at all sampling locations. Table 5.4-1 summarizes the sampling methods at each sampling station for each sampling event. A total of six transect locations located at RM 2, mouth of Multnomah Channel, RM 3.9, RM 6.3, RM 11 and RM 16 were sampled;~~,~~ due to flow conditions and sample event objectives, ~~although~~ not all transects were sampled during all sampling events. Transects were sampled in three ways: as a vertically-integrated [VI], equal discharge increment transect [EDI-VI]; as a near surface equal discharge increment transect and near bottom equal discharge increment transect pair [EDI-NS/NB]; and as a vertically-integrated, three segment (East, Mid-channel, West) ~~equal discharge increment~~ transect [~~EDI~~ VI (E,M,W)][2]. Three single ~~-~~point vertically-integrated samples were collected during Round 2A low flow conditions only (W010, W014, and W020) to support the baseline human health risk assessment. The remaining Round 2A single~~-~~point samples were collected in support of the baseline ecological risk assessment as near bottom samples. Round 3A single~~-~~point samples were collected as near surface and near bottom pairs. Siltronic collected peristaltic single ~~-~~point samples, and NW Natural and the City of Portland collected surface water grab samples. ~~Both grab and peristaltic samples (single-point samples) were collected by Siltronic and NW Natural.~~ Not all samples were analyzed for every analyte. Each subsection that follows will discuss which samples were analyzed for ~~that~~each IC ~~contaminant~~.

[2] A single vertically-integrated sample was collected from the mid-point of each transect segment.

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A total of 16~~23~~ peristaltic sample locations and seven peristaltic and XAD stations were sampled ~~Peristaltic samples (single-point samples) were only collected during Round 2A low flow conditions (i.e., November 2004, March 2005, and July 2005) at 17 stations.~~ during the Round 2A low flow conditions and six peristaltic and XAD stations were sampled during the Round 3A low flow conditions (Table 5.4-2). Twenty single-point peristaltic stations (W001-W004, W006-W010, and W012-W022) and four single-point peristaltic and XAD stations were sampled (W013, W015, W016, W018) during each of the three Round 2A sampling events (Table 5.4-1). Both peristaltic and XAD samples were collected for all the low flow transect samples in Round 2A. Three Round 2A transect locations (W005, W011, and W023) were collected during low flow conditions as EDI-VI. Four Round 3A transect locations (W005, W011, W024, and W027) were collected as EDI-NS/NB and the other two Round 3A transect locations (W023 and W025) were collected as ~~EDI~~ VI (E, M, W). ~~Some samples were collected as vertically-integrated samples while others were collected only near the bottom of the water column.~~ Replicates were ~~only~~ collected based on a 5% target frequency at the following single-point stations: W013 (peristaltic and XAD) and W016 (peristaltic only) during November 2004; W013 (peristaltic and XAD) and W002, W004, and W016 (peristaltic only) during March 2005; and W002 and W016 (peristaltic only) and W013 (peristaltic and XAD ~~only~~) during July 2005. A total of 92~~1~~ peristaltic samples and 38 XAD samples were collected to represent the low flow conditions of the river (Table 5.4-3). As summarized in Table 5.4-4, ~~S~~samples collected during this flow regime include:

- 61~~59~~ peristaltic and 15 XAD single-point, near-bottom samples;
- ~~8~~9 peristaltic single-point, vertically-integrated samples;
- 9~~15~~ peristaltic and 9~~15~~ XAD transect, EDI-VI samples;
- 2 peristaltic and 2 XAD east-channel VI transect samples, 2 peristaltic and 2 XAD mid-channel VI transect samples, and 2 peristaltic and 2 XAD west-channel VI transect samples;
- 4 peristaltic and 4 XAD transect, EDI-NS samples; and
- 4 peristaltic and 4 XAD transect, EDI-NB samples.

~~XAD samples (single-point samples) were only collected during Round 3A storm water influence flow (November 2006) and high flow (January 2007) conditions. Single point XAD samples were collected in near-bottom and near-surface pairs. Both grab and peristaltic samples (single-point samples) were collected by Siltronic and NW Natural.~~

~~XAD transect samples were collected at RMs 2, 3.9, 6.3, 11, 16 and Multnomah Channel. Samples collected at RMs 3.9, 6.3 and 11 were spatially integrated across the entire width and depth of the channel based on a flow-weighted method (USGS 2000).~~

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~~The samples collected at RMs 3.9 and 6.3 were collected as near-bottom and near-surface pairs while the samples collected at RM 11 were collected as vertically-integrated samples. These samples were collected during all sampling events except the Round 3A high flow sampling event (January 2006) at RM 6.3 and only a near-surface sample was collected at RM 3.9 during this sampling event. XAD transect samples were collected at RM 2 and in Multnomah Channel only during Round 2A low flow (November 2007) and Round 3A low flow (September 2006), storm water influenced flow (November 2006), and high flow (January 2007). Samples collected at RM 2 were collected as vertically-integrated samples at 3 locations (eastern shore, mid-channel, and western shore) while samples collected in Multnomah Channel were collected as near-bottom and near-surface pairs. XAD transect samples were collected at RM 16 only during Round 3A sampling (January 2006, September 2006, November 2006, and January 2007) as near-bottom and near-surface pairs; only a near-surface sample was collected during the January 2006 sampling event.~~Storm water-influenced flow conditions were only sampled once during Round 3A (November 2006). Both peristaltic and XAD samples were collected at all six transect locations (W005, W011, W023, W024, W02~~1~~5, and W027) and 12 single-point stations (W026 and W028-W038) during this sampling event (Table 5.4-1). Four of the transect locations (W005, W011, W024 and W027) were sampled as EDI-NS/NB. The other two transect locations (W023 and W025) were sampled as ~~EDI~~ VI (E, M, W). All the single-point samples were collected as NS/NB pairs. Replicates were collected at single-point stations W033 (peristaltic and XAD) and W036 (peristaltic only). A total of 40~~2~~ peristaltic samples and 42 XAD samples were collected to represent the storm water-influenced flow conditions of the river (Table 5.4-3). As summarized in Table 5.4-4, ~~S~~samples collected during this flow regime include:

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- 14 peristaltic and 13~~4~~ XAD single-point, near surface samples;
- 14 peristaltic and 13~~4~~ XAD single-point, near-bottom samples;
- 2 peristaltic and 2 XAD east-channel VI transect samples, 2 peristaltic and 2 XAD mid-channel VI transect samples, and 2 peristaltic and 2 XAD west-channel VI transect samples~~6 peristaltic and 6 XAD transect, EDI-VI samples~~;
- 4 peristaltic and 4 XAD transect, EDI-NS samples; and
- 4 peristaltic and 4 XAD transect, EDI-NB samples.

High flow conditions were sampled twice during Round 3A (January 2006 and January-March 2007). In January 2006, peristaltic and XAD samples were collected at three transects (W005, W023, and W024). Due to safety concerns and sampling challenges associated with the extreme high -flow conditions, the January 2006 samples were collected mid-channel at a single fixed depth for each of the three transect stations that were sampled. No vertical integration was performed.~~Two samples, W005 and W023, were collected as EDI-VI samples. The third sample, W024, was collected as EDI-~~

~~NS/NB samples.~~ One replicate was collected at W023~~4~~ for the peristaltic~~NS~~ sample only. Both peristaltic and XAD samples were collected at all six transects and 12 single-point stations (W026 and W028-W038) during the January-March 2007 sampling event. Four of the transect locations (W005, W011, W024 and W027) were sampled as EDI-NS/NB. The other two transect locations (W023 and W025) were sampled as ~~EDI~~ VI (E, M, W). Stations W023-M and W025-M were first sampled in January 2007, and then re-occupied in March 2007 (W023-M2, W025-M2) due to changing flow conditions. All the single-point samples were collected as NS/NB pairs. NS and NB replicates were collected at single-point station W033 (peristaltic only) during the January-March 2007 event. A total of ~~46~~4 peristaltic samples and 43 XAD samples were collected to represent the high flow conditions of the river (Table 5.4-3). As summarized in Table 5.4-4, samples collected during this flow regime include~~s~~:

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- 13~~2~~ peristaltic and 12 XAD single-point, near surface samples;
- 1~~2~~3 peristaltic and 12 XAD single-point, near-bottom samples;
- 2 peristaltic and 2 XAD east-channel VI transect samples, 4 peristaltic and 2 XAD mid-channel VI transect samples, and 2 peristaltic and 2 XAD west-channel VI transect samples~~11 peristaltic and 10 XAD transect, EDI-VI samples~~;
- 4~~5~~ peristaltic and 4~~5~~ XAD transect, EDI-NS samples; and
- 4 peristaltic and 4 XAD transect, EDI-NB samples.

Since the single-point stations sampled during the low flow event are located in different areas of the site than the stations sampled during the other flow events, the data sets cannot be compared to each other because they represent different areas of the site. While the six transects were sampled in almost all the sampling events, different sampling methods were used to collect the samples. While the discussion will still compare concentrations at the river transects, it must be understood that there is uncertainty associated with the transect data between flow events.

~~A summary of the sampling events, including dates of collection, flow rates, and relative flow conditions, are presented in Table 5.3-1. Average discharge rates (recorded as cfs) for each event are based on measurements collected by the USGS at the stream flow station located upstream of the Morrison Bridge at RM 12.8 (Station 14211720). Flow measurements from the USGS gauge at this station are collected every 30 minutes and were used to calculate flow rates for each of the seven sampling~~

~~events.[3] It should be noted that discharge rates below 20,000 cfs measured at this station are considered to be unreliable by the USGS. Therefore, the average discharge rates calculated for the low-flow events should be considered estimates.~~

~~Surface water data from the Study Area (RM 1.9–11.8) and areas immediately upstream and downstream of the Study Area were generated during the Round 2A and 3A collection programs. Summary statistics for ICs for~~ Round 2A and 3A~~[4]all sampling events are provided in Tables 5.4-3-2 through 5.4-83-7. TSS and organic carbon data from the three other data sets were incorporated into the discussions of water chemistry presented in this nature and extent evaluation. No other analytes in the other data sets were included in the data statistics. In addition, summary statistics for all chemicals~~other key contaminants ~~measured in surface water are presented in Tables D3.2-1 through D3.2-6.~~

Uncertainty associated with the surface water data is related primarily to the representativeness of the analytical data set. The data sets are derived from grab samples instead of time-weighted composites, and a limited number of samples were collected under a limited number of flow conditions. This prohibits a quantitative statistical evaluation of temporal and flow variability in surface water quality and is an important source of uncertainty of unknown magnitude. Further, the limited number of data points should not be construed as defining the magnitude and extent of the surface water contamination in localized areas that may be problematic and will need to be addressed further in remedial design. However, the data presented ~~is~~are sufficient to determine the extent of contamination at the site and to determine the need for action. As discussed in Section 2, only ~~high quality~~ Category 1 QA2 data a~~were~~ used in these ~~nature and extent~~ discussions.

~~River Conditions during~~

~~5.4.1.2~~5.4.2 Round 2A and 3A Sample Collection ~~Conditions~~

~~Surface water samples were collected at 23 target locations from RM 2 to 11 in the LWR during three Round 2A sampling events in 2004 and 2005. Single-point samples were collected by peristaltic pump at all locations. Additional samples were collected by employing the high-volume XAD sampling method (description of XAD sampling method in Section 5.3.1.2 below) at seven of the 23 locations, including three cross-sectional river transects and four discrete locations. All high-volume samples were collected using an Infiltrex 300 water collection system which pumped water through an inline 0.5-micron glass fiber pre-filter and then through an XAD-2 resin column. Each filter and the resin column was extracted and analyzed separately to determine chemical concentrations in the particulate and dissolved phases of each sample, respectively. The~~

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~~[3] The flow rate values presented here are daily mean stream flow measurements from the USGS National Water Information System, http://waterdata.usgs.gov/nwis. These values were taken from the USGS Web site on June 16, 2008, and are considered to be draft and subject to change by USGS.~~

~~[4] ICs were not analyzed in other data sets used in this evaluation, so they are not included in the summary statistics.~~

~~Round 2A surface water study is described in Section 2.1.3.4 of the Round 2 Report (Integral et al. 2007). The Round 2A Surface Water SCSR (Integral 2006j) provides details regarding the sampling program, sample collection procedures, and laboratory analyses.~~

~~During the Round 3A sampling events, surface water was collected at 18 target locations from RM 2 to 16 in 2006 and 2007. A transect station located at the upper end of Multnomah Channel (RM 2.9) was added to the program to provide a better understanding of the flux of chemicals exiting the Study Area via Multnomah Channel; and a transect station at RM 16 was added to assist with the analysis of upstream sources and loading into the Study Area. Peristaltic and high-volume samples were collected from 18 stations, including 6 transects and 12 single-point locations. Table 5.3-8 summarizes sampling methods at each station for all Round 2A and 3A sampling events.~~

~~Peristaltic surface water samples were analyzed for conventional analytes, metals, and organic compounds (PCB Aroclors, organochlorine pesticides, and SVOCs). High-volume samples were analyzed by high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) for PCB congeners, PCDD/Fs, organochlorine pesticides, phthalate esters, and PAHs.~~

A summary of the sampling events, including dates of collection, flow rates, and relative flow conditions, are presented in Table 5.4-5. Average discharge rates (recorded as cfs) for each event are based on measurements collected by the USGS at the stream flow station located upstream of the Morrison Bridge at RM 12.8 (~~S~~station 14211720). Flow measurements from the USGS gauge at this station are collected every 30 minutes and were used to calculate flow rates for each of the seven sampling events.[5] It should be noted that discharge rates below 20,000 cfs measured at this station are considered to be unreliable by the USGS. Therefore, the average discharge rates calculated for the low -flow events should be considered estimates.

The ~~seven Round 2A and 3A~~ surface water sampling events and their corresponding flow rates are presented against the backdrop of the average year (1972–2008) hydrograph measured at Morrison Bridge ~~(RM 12.8)~~ o~~i~~n Figure 5.4~~3~~-1. Overall, the sampling events were well distributed over the average water year, capturing the range of flow conditions, including base flow, rising limb, peak flow, and falling limb conditions. Additionally, the November 2006 sampling captured a storm water-influenced flow event ~~during~~at the onset of the transition from a low -flow period to a high flow period. Figures 5.4~~3~~-2a-d ~~through 5.3-5~~ present the actual annual hydrograph measured at Morrison Bridge (RM 12.8) and hyetograph during each year of sampling

[6] ~~At each Round 2A transect station, samples were spatially integrated across the entire width and depth of the channel based on a flow-weighted method (USGS 2000). At each transect, the river was divided into equal flow subareas (i.e., EDIs) using existing bathymetry and river flow data. VI samples were collected from 1 ft below the water surface to within 1–3 ft of the river bottom in each subarea; these samples were combined to produce integrated river cross-section composite samples.~~

(2004–2007), including daily average and historical average (1978–2008) discharge rates and daily precipitation levels and identifies the sampling events collected during each year. Several rainfall events occurred during the November 2004 sampling event, and one day of measurable rainfall occurred during each of the March and July 2005 sampling events.

The seasonal cycle of water discharge in the Willamette River is also apparent ~~in~~ on Figure 5.4~~3~~-1. Annual low water levels occur during the summertime regional dry season, and flows increase during the wetter winter months (November to March). Furthermore, a distinct and persistent period of relatively high water levels occurs from late May through June when Willamette River flow into the Columbia is slowed by high-water stage/flow in the Columbia River during the spring freshet in the much larger Columbia River Basin. ~~As described in Section 3.1.3, water levels and currents in the LWR can be influenced by the Columbia River in several ways. The most apparent influence occurs during spring and summer when high flows from the Columbia River act as a hydraulic dam to the Willamette River, resulting in rises in the Willamette River stage. The Columbia River flow drops as the summer progresses and this effect is diminished. During the winter, high seasonal flows on the Willamette River pass through to the Columbia River, which may have diminished flows due to retention at dams.~~The flow regime can influence the concentration of contaminants in the water column.

Flow measurements were not collected at the lower end of the ~~s~~Study ~~a~~Area where the river flows either into the Columbia River or into Multnomah channel. To better understand the ~~Hydrodynamic model estimates of~~ flow dynamics at the lower end of the Study Area, a hydrodynamic model (discussed in Section 6) was used to estimate these flows. The model shows that the relative stages of the Columbia and Willamette rivers determine~~s~~ the fraction of the Willamette River flow, which flows down Multnomah Channel (WEST 2006a). Figure 5.4~~3~~-3~~6~~ presents the average annual hydrograph, based on modeled discharge rates for 2003 through 2007, for RM 4, RM 2, and Multnomah Channel. The Morrison Bridge (RM 12.8) 25-yr average hydrograph is also shown for comparison.

Figure 5.4~~3~~-4~~7~~ presents the modeled daily average flows for 2003 through 2007~~,~~ and highlights the time periods when surface water samples were collected at RM 4, RM 2, and Multnomah Channel. A few key observations are apparent in these figures. First, for a significant portion of each year, generally May through September, the relatively higher Columbia River stage drives a reversal in flow direction at RM 2. During these periods, the Multnomah Channel flow increases and includes the entire Willamette River flow plus some flows from the Columbia River. Second, Figure 5.4~~3~~-4~~7~~ shows that surface water sampling events at the RM 2 and Multnomah Channel sample transects did not occur during these flow reversal periods; rather, sampling was conducted when the Willamette River flow was in the downstream direction, and flows split between Multnomah Channel and the main stem. This indicates that surface water

samples collected at RM 2 and Multnomah Channel are representative of Willamette River water and are not strongly influenced by mixing with Columbia River water.

Tidal action also compounds the hydrology and interplay of the two rivers, and affects the Willamette River upstream as far as Portland Harbor and beyond. The high (i.e., flood) tide can influence Willamette River levels by up to 3 ft in Portland Harbor when the river is at a low stage. These tidal fluctuations can result in short-term flow reversals (i.e., upstream flow) in Portland Harbor during times of low river stage combined with large flood tides. Tidal changes were observed at multiple stations during the surface water sampling events. At this time, there is not adequate high-resolution discharge information to determine the potential influence of tidal fluctuations and water mixing on surface water sampling results; however, the overall tidal impact is not expected to be significant.

~~5.4.1.3 Sampling Methods~~

~~Sampling stations included both river-wide transects and single-point sampling stations at specific locations. Transect samples involved vertically integrated (VI) sample composites collected from multiple lateral substations across the width of the river channel. Transect sampling is designed to estimate integrated water concentration and flux through a cross-section of the river or fraction of a cross-section at a point in time. Single-point samples are stationary samples or sample pairs at a constant depth.~~

~~Round 2A surface water samples were collected at three transect stations (RM 4, 6.3, and 11) and 20 single-point stations. Round 2A transect samples were collected as equal discharge increment (EDI)[6] composite samples across the channel. Round 2A single-point samples were collected as either NB or VI samples. Single-point NB samples were collected between 1 and 3 ft off the river bottom in water less than 20 ft deep. Single-point VI samples were vertically integrated from 1 ft below the water surface to within 1 to 3 ft of the river bottom at BHHRA stations.~~

~~Round 3A surface water samples were collected at six transect stations (RM 2, 2.9 [Multnomah Channel], 4, 6.3, 11, and 16) and 12 single-point stations. Round 3A transect samples were collected as either a single EDI composite sample, a pair (not composited) of NB/NS[7] samples horizontally integrated across the channel, or three VI composite samples at three points across the channel (located at east, middle, and west channel; VI-EMW). Round 3A single-point samples were collected as a pair (not composited) of NB/NS samples at a stationary point in the channel. The Round 3A single-point sampling stations were selected to provide water chemistry data in areas in~~

[6] ~~At each Round 2A transect station, samples were spatially integrated across the entire width and depth of the channel based on a flow-weighted method (USGS 2000). At each transect, the river was divided into equal flow subareas (i.e., EDIs) using existing bathymetry and river flow data. VI samples were collected from 1 ft below the water surface to within 1–3 ft of the river bottom in each subarea; these samples were combined to produce integrated river cross-section composite samples.~~

[7] ~~Surface water was collected from two points in the water column. The NB sample was collected at a depth of 1 ft off the river bottom. The NS sample was collected 3 ft below the surface.~~

higher flow conditions than were sampled in Round 2 to support source identification and the FS. Selected Round 3A single-point stations were relocated into deeper water to accommodate the NB/NS sampling.

XAD water samples were passed through a 0.5-µm filter and an XAD-2 resin column. Chemical mass captured on the filter provides the particulate fraction concentration, while chemical mass on the resin column provides the "dissolved fraction" concentration. Note that this approach to definition of the dissolved and particulate fractions of the whole sample constitutes an operational definition of these fractions. In reality, it is likely that colloidal-sized particles less than 0.5 µm in diameter are present in the "dissolved" fraction. This is a critical consideration in review of the data set.

A summary of the sampling methods employed at each station for all sampling events is presented in Table 5.3-8. Sampling techniques at each station included both standard (peristaltic) and high-volume (XAD) methods as described in detail in the surface water sampling FSPs (Integral 2004c, 2006m).

Sample locations and samples are labeled on the figures and tables according to the following scheme:

- High-volume XAD samples were collected as two analytical samples. The surface water particulates associated with the XAD filter are labeled in tables and figures as XAD-F or XAD filter. The sample from the XAD column represents the dissolved phase and is labeled as XAD-C or XAD column.
- In Round 3A, near-bottom and near-surface samples were collected and are labeled as NB and NS in the tables and figures.
- Also in Round 3A, three VI composite samples were collected at three points across the channel and these stations and samples are labeled as -E, -M, or -W for the samples collected on the east, mid-channel, and west sides of the river.

5.4.1.4 Data Processing and Calculations

Commented [A4]: This information is discussed in Section 2 and Appendix A.

For all analyte group total calculations in this report (total PCB congener, total PCDD/Fs, total DDx, and total PAHs), the RI method for summing parameters was applied.[8] All particulate and dissolved total PCB congener and total PCDD/F concentrations were above detection limits. One total DDx particulate concentration was non-detect; in this case, a value of one-half the detection limit was used in calculations and plots.

To support the data analysis presented in this section, several terms were calculated from the surface-water data set: the fraction of organic carbon (f_{oc}), POC, average

[8] For all totals, zero is always assigned for individual non-detect values included in the group total. If any of the values included in a total are estimated (J-qualified), then the total value is estimated (J-qualified). If all analytes in a total are non-detects, then the highest detection limit is used for the total and the total is U-qualified. For additional information, see Section 2.1.4.

~~particle IC concentration (C_s), and apparent organic carbon partitioning coefficient (K_{oc}). The f_{oc} describes the percent of mass of the suspended solids that is made up of organic material, which is truly a TSS-normalized version of the POC value. The f_{oc} was calculated from the peristaltic TOC, dissolved organic carbon (DOC), and TSS values, using the following equation:~~

$$f_{oc} = \frac{TOC - DOC}{TSS} = \frac{POC}{TSS}$$

~~For the few cases where the sample DOC was greater than TOC, the POC and f_{oc} values were set equal to zero.~~

~~The POC was calculated in this study to represent how much adsorbed (to suspended particulate material) organic carbon was present in the surface water in each sample. This value was simply estimated by subtracting the peristaltic sample DOC results from the corresponding peristaltic sample TOC results.~~

$$POC = TOC - DOC$$

~~5.4.1.5 LWG Member Sampling Events~~

~~LWG members Siltronic, NW Natural, and the City of Portland conducted independent surface water sampling, as summarized below:~~

- ~~Siltronic – In May and June 2005 during low flow river conditions, Siltronic collected 22 near-bottom surface water samples at stations located from RM 6.4 to RM 6.5. Samples were generally collocated with TZW sampling locations. Samples were collected with a peristaltic pump and analyzed for conventional parameters, VOCs, and SVOCs. The Supplemental Investigation Report (MFA 2005b) presents additional information on the Siltronic surface water samples.~~

- ~~NW Natural – Surface water grab samples were collected at 20 locations near the Gasco site from RM 5.9 to RM 6.7. At each location, near-surface, mid-depth, and near-bottom samples were collected in October 2007, in low-flow conditions, during three tidal periods: ebb, slack high, and slack low. A total of 180 surface water samples were tested for conventional parameters, cyanide, and select metals. The Gasco surface water samples are discussed in more detail in the Offshore Groundwater Field Sampling Approach (Anchor 2006b) and the Offshore Investigation Report (Anchor 2008b).~~

- ~~City of Portland – The City of Portland collected surface water TSS data between February 5, 1992 and March 15, 2006 (Sanders 2006). The surface water samples were collected at a 10-ft depth from the east, middle, and west locations along transects at RM 1.1, 6.8, 8.8, 12.7, 17.9, and 20, and were composited by transect.~~

Commented [A5]: This information was incorporated with discussion on data set.

~~TSS and organic carbon data from these three LWG member data sets were incorporated into the discussions of water chemistry presented in this nature and extent evaluation. No other analytes in the LWG member data sets were included on the surface water indicator chemical list.~~

~~5.4.2 Data Uncertainties~~

~~Uncertainty associated with the surface water data is related primarily to the representativeness of the analytical data set. The data sets are derived from grab samples instead of time-weighted composites, and a limited number of samples were collected under a limited number of flow conditions. This prohibits a quantitative statistical evaluation of temporal and flow variability in surface water quality and is an important source of uncertainty of unknown magnitude. As discussed in Section 2, only high quality Category 1 QA2 data were used in these nature and extent discussions.~~

~~5.4.3 Indicator Chemicals in Surface Water~~

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~~The IC list for surface water is presented in Table 5.0-2. The selection of ICs was guided by the considerations provided in Section 5.0, in coordination with EPA. A total of 22 individual analytes and calculated chemical sums were identified as ICs for surface water. Low frequencies of detection in surface water samples resulted in fewer ICs than for sediment. Indicator chemicals for surface water are organized as follows:~~

- ~~PCBs~~
  - ~~Total PCBs*~~
  - ~~PCB TEQ (ND=0)~~
- ~~PCDD/Fs~~
  - ~~Total PCDD/Fs*~~
  - ~~TCDD TEQ (ND=0)*~~
- ~~DDx~~
  - ~~Total DDx (total of 2,4' and 4,4' DDD, DDE, and DDT)*~~
  - ~~Total of 2,4' and 4,4' DDT~~
  - ~~Total of 2,4' and 4,4' DDE~~
  - ~~Total of 2,4' and 4,4' DDD~~
- ~~Pesticides (non-DDx)~~
  - ~~Total chlordanes*~~
  - ~~gamma-HCH~~
  - ~~Aldrin*~~

- Dieldrin*

- PAHs
  - Total PAHs*
  - Total LPAHs
  - Total HPAHs
  - Total cPAHs BaPEq values
  - BAP
- SVOCs
  - Hexachlorobenzene
- Metals
  - Arsenic*
  - Copper*
  - Lead
  - Zinc.*

This section focuses on the distribution of a subset of 11 ICs, which are indicated with an asterisk (*) in the above list, in surface water in the Study Area, as well as upstream (i.e., RM 16) and at Multnomah Channel (approximately RM 2.9). The 11 ICs in surface water were selected from the chemicals for presentation and discussion in the site-wide CSM (Section 10). Four of these chemicals – total PCBs, total PCDD/Fs, total DDx, and total PAHs – were selected for in depth discussion. The discussion focuses primarily on a description of the data set for each analyte, including concentration ranges for the various sampling event types (low-flow, high-flow, and stormwater-influenced) and frequency of detection. For these four bounding ICs, the narrative also includes the relationship of chemical concentration to location, flow rate, association with suspended solids, and associated organic carbon.

The discussion of the other six ICs in the subset is abbreviated and includes a description of the data set, concentration ranges, and frequency of detection, with references to figures and tables to provide a complete picture of the distribution of those chemicals. Figures for the remaining 11 chemicals are included in Appendix D3.

The nature and composition of the four bounding ICs are discussed to provide background on their environmental chemistry and to provide a site-wide perspective on their distribution. Chemical distributions across abiotic and biotic media in relation to specific potential sources are discussed in more detail in Section 10. Finally, surface water sampling results are compared to various water screening values in Appendix D3.3. Contaminants that exceed one or more screening values are identified and will be

included in the contaminant mobility evaluation in the draft FS. Contaminants that pose potential risk to humans are discussed in the BHHRA (Appendix F).

5.4.4 Description of Surface Water Presentation Tools

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The surface water chemistry distributions and supporting information are depicted in several graphical formats: hydrographs and hyetographs of sampling events, discharge rates, and precipitation events (Figures 5.3-1 through 5.3-7), and histograms of sample concentrations for all sampling events for the ICs, along with line plots, stacked bar charts, and scatter plots for the bounding ICs (Figures 5.3-8 through 5.3-120). The stacked bar charts and scatter plots present the data by river mile. Station W027 (RM 2.9) was located in Multnomah Channel, and Stations W018 (RM 8.3), W020 (RM 9.1), W021 (RM 8.7), and W035 (RM 8.5) were located in Swan Island Lagoon. Multnomah Channel and Swan Island Lagoon are indicated by "MC" and "SIL", respectively, on the histograms.

Hydrographs and Hyetographs: The hydrographs show the average discharge rates during the Round 2A and 3A surface water sampling events and the hyetographs show precipitation events and amounts to provide perspective on the timing of the Round 2A and 3A sampling events and the specific conditions prior to, during, and after each event.

Histograms: The histograms provide a graphical summary of the distribution of chemicals for all the surface water sampling events. For each analyte, data are presented in two types of histograms: data sorted by flow event type (high-flow, low-flow, and stormwater-influenced) and data sorted by location in the river channel (west and east channel and transect locations). For the XAD samples (units in pg/L), the individual data points are composed of shaded stacked bars to distinguish between the XAD column and XAD filter samples. The bars are color-coded to distinguish between the single-point samples (blue) and the transect samples (orange). The non-detected samples are displayed with a hatch pattern or open bar. The same scheme is used for the peristaltic samples (units in µg/L), with shaded stacked bars for total and dissolved fractions and blue and orange colors for the single-point and transect samples. In Round 2, stations were analyzed for PAHs in both the XAD and peristaltic samples; the histograms for the peristaltic samples only display samples where PAHs were not analyzed in the XAD sample.

Line Plots: The line plots present the concentrations of the bounding ICs for each flow type (high-flow, low-flow, stormwater-influenced) at the transect stations for all surface water sampling events. The squares, diamonds, and triangles represent the data points. Prior to generating the plots, data were averaged so that only one value per transect per sampling event was used. NB and NS total (dissolved plus particulate) concentrations were averaged for samples from stations W027 (Multnomah Channel), W005 (RM 4), W011 (RM 6.3), and W024 (RM 16) and east, west, and mid-channel total concentrations were averaged for stations W025 (RM 2) and W023 (RM 11), where

~~applicable. The data for the 2007 high-flow event is displayed in two colors because this event was completed in two phases with a stand-down period between high-flow conditions.~~

~~**Scatter Plots:** Scatter-plot presentations of the surface water data show concentrations of the four bounding ICs by river mile, flow, TSS, and organic carbon, and particulate versus dissolved concentrations are displayed for detailed evaluation of the results. The symbols on the scatter plots distinguish between flow types (high-flow, low-flow, stormwater-influenced) and single-point and transect samples.~~

~~**Stacked Bar Charts:** Bar charts are designed to reveal distinctive patterns in the relative abundance of bounding IC components. These graphs provide a line showing concentrations of the IC (i.e., totals) on a logarithmic scale, but do not display concentrations of the analyte components (e.g., homologs, isomers). The analyte components are shown as a percent of the total concentration. The samples are sorted by flow type and also by river mile within each flow type. Non-detect values were set equal to zero for these charts.~~

~~5.4.5~~5.4.3 Suspended Solids

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Suspended sediment loads ~~and dynamics~~ are potentially an important component of the Lower Willamette River physical system~~.~~ ~~and~~ TSS data have been collected as part of the surface water data collection effort to understand distributions and patterns of ~~chemical~~ contaminant concentrations. ~~Peristaltic samples were collected and analyzed for TSS (reported in mg/L) during Round 2A and 3A. TSS concentrations in surface water are presented as a histogram arranged by flow conditions (low-flow, high-flow, and stormwater-influenced flow) and river mile in Figure 5.3-8. The same data are presented as a histogram by channel position (west and east channel and transect locations) on Figure 5.3-9. TSS data collected by LWG members are presented in Figures 5.3-10a, 5.3-10b, and 5.3-11.~~As stated in Section 3, evaluations overall indicate that a positive correlation exists between TSS concentrations and flow rate in the Lower Willamette River.

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Total organic carbon (TOC) comes from decaying natural organic matter as well as synthetic sources, such as oil and coal. Persistent organic pollutants, such as PCBs, dioxin/furans, and chlorinated pesticides, tend to accumulate in the organic fraction (f_{oc}) of sediments and soils, although they can dissolve in appreciable quantities in aquatic environments due to the dissolved organic carbon (DOC) and possible presence of colloids[9] in the water column. Organic carbon in the suspended sediment is a strong determinant in the adsorption of low soluble organic contaminants (i.e., persistent organic pollutants). DOC is extremely important in the transport of metals in the aquatic systems. Metals form extremely strong complexes with DOC, enhancing metal solubility while also reducing metal bioavailability.

[9] Colloids are very small organic or mineral particles that can barely be seen by the naked eye. Separation of colloids from the aqueous phase is difficult and very little is known about their composition and behavior.

~~TSS measured in single-point samples collected during low-flow conditions ranged from 3 J to 15 J mg/L at Station W013 (RM 6.7) in March 2005. Concentrations in transect samples during low-flow ranged from undetected (at a detection limit of 1 U mg/L) to 25 J mg/L at Station W011 (RM 6.3) in July 2005.~~

~~TSS measured in single-point samples collected during high-flow conditions ranged from 13 to 60 mg/L at Station W031 (RM 6.1) in January 2007. Transect concentrations during high-flow ranged from 9 to 62 mg/L at Station W023 (RM 11) in January 2006.~~

~~TSS concentrations in single-point samples collected during the November 2006 stormwater-influenced event ranged from 2 to 7 mg/L at Station W026 (RM 2.1). Concentrations in transect samples during the stormwater-influenced event ranged from undetected (at a detection limit of 1 UJ mg/L) to 6 mg/L at Station W005 (RM 4).~~

~~LWG members NW Natural and the City of Portland also collected TSS data from the Willamette River. The NW Natural TSS data ranged from 5 U to 14 mg/L. The City's TSS data corresponding to the timing of the Round 2A events and the Round 3A January 2006 high-flow event (extent of TSS data collected) are presented in Figures 5.3-10b and 5.3-11. TSS measurements during this time period ranged from undetected (2 mg/L) to 42 mg/L. The NW Natural and City of Portland TSS measurements collected during the Round 2A and 3A sampling events were comparable to the range of LWG TSS (undetected at 1 mg/L to 62 mg/L). Looking at the complete City of Portland data set collected from 1992–2007, the range of TSS concentrations (0.4 to 243 mg/L) measured in the City of Portland composite samples was wider than that measured by LWG or the City of Portland during the time period of the Round 2A and 3A sample collection events.~~

~~The TSS concentrations as a function of flow rate for all samples in the surface water data set are presented in Figure 5.3-12. A general trend of increasing TSS concentration with increasing flow rate is more readily apparent in Figure 5.3-13, which presents TSS concentration as a function of river mile. Figure 5.3-14 presents a line plot of TSS data collected at surface water transect stations, presented by event. Both of these figures show that TSS concentrations varied over a large concentration range (single-point and transect samples) upstream from RM 16 to 4. By RM 2, there is a decrease in the TSS concentration range.~~

Figures 5.4~~3-1~~5 and 5.4~~3-1~~6 present the f_{oc} on the TSS in each surface water sample as a function of flow rate and river mile, respectively. The surface water transect particulate and dissolved organic carbon data are presented by event on Figures 5.4~~3-1~~7 and 5.4~~3-1~~8. The f_{oc} values on the TSS range from 0 to 20 percent in the low-flow samples and 0 to 50 percent in the storm water-influenced samples. Conversely, the f_{oc} on the TSS in high-flow samples is distinctly lower, ranging from 0 to less than 4 percent, suggesting the introduction of suspended particles with low organic carbon content during high-flow events. Generally low f_{oc} values may be a function of larger

particles (lower surface area per volume and therefore fewer organic carbon binding sites) introduced during high -flow conditions.

Figure 5.~~43-1~~9 presents a scatter plot of f_{oc} and TSS that summarizes the overall trend of solids concentrations and f_{oc} in the data set. High -flow samples tend to exhibit lower f_{oc} associated with TSS. The shape of the curve is largely driven by the fact that f_{oc} is a function of TSS. The suspended solids associated with the storm water-influenced samples appear to have the highest levels of organic carbon content. The TSS concentrations and corresponding f_{oc} values vary somewhat between flow types, and the low -flow samples appear to fall between the high -flow and storm water-influenced samples based on the level of organic carbon. There is the possibility that there may be local nearshore effects at the point of discharge that were not captured in the surface water sampling data set.

~~Some portion of the organic carbon content of suspended solids may be attributable to phytoplankton living in the Willamette River. In riverine systems, plankton are generally considered a minor component of the biota (Allan 1995; Horne and Goldman 1994). Plankton have limited powers of locomotion and therefore cannot maintain their presence in rapidly flowing waters (Wetzel 2001). Some species are conspicuously absent from running waters, whereas other taxa found in riverine systems tend to be associated with sheltered areas such as shallow littoral zones and backwater eddies and in pools in streams with well-developed pool-riffle hydrology (Pennak 1989). The high flow surface water sampling events were conducted in January and February, when plankton populations would be expected to be small due to seasonal conditions. This factor, in addition to the increase in large, low organic carbon particles, may contribute to the relatively low f_{oc} values measured in the high flow events.~~

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5.4.4 Total PCBs in Surface Water

Total PCB data are summarized in Tables 5.4-6 through 5.4-11. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-8, and 5.4-10. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and 5.4-11a-d. All PCB surface water sample results are presented in Table 5.4-12 by sample event and sample ID number.

Dissolved and particulate PCB congener concentrations in surface water XAD columns and filters and PCB Aroclor concentrations from the peristaltic pumps are presented in stacked bar graphs by flow event and by river mile/channel position on Figures 5.4-10 and 5.4-11.

Total PCB concentrations at the transect locations as a function of flow rate is presented on Figure 5.4-12. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

Figures 5.4-13a-b present a scatter plot of all total PCB surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low -flow, storm water-influenced, or high flow.)

~~5.4.7~~

5.4.4.1 Total PCB Data

Total PCBs were analyzed as PCB Aroclors by EPA method 8081 in 51 of the total 157 peristaltic samples collected; 41 SP-NB samples, nine SP-VI samples, and one transect EDI-VI sample. High-volume surface water samples (XAD samples) were analyzed ~~for~~ as PCB congeners ~~(reported in units of pg/L)~~ by HRGC/HRMS in 120.5[10] of the total 123 XAD samples collected; 25 SP-NS samples, 39.5 SP-NB samples, 31 transect EDI-VI samples, 13 transect EDI-NS samples, and 12 transect EDI-NB samples~~, and peristaltic samples were analyzed for PCB Aroclors (reported in units of µg/L) by routine methodology (i.e., EPA method 8081)~~. ~~Stacked bar graphs depicting Total PCB concentrations in the surface water dissolved (XAD column) and particulate (XAD filter) samples by flow condition and river mile are presented in Figures 5.4-10 and 5.4-11.~~

~~Total Aroclor concentrations ranged from below detection limits to 0.015 µg/L. There are 1,000,000 pg in 1 µg.~~ PCB Aroclors were not detected in the majority of the peristaltic samples (45 of ~~approximately 90 percent~~51 non~~un~~detect sample~~s~~d) with detection limits ranging from 0.0025 to 0.0027 µg/L, which is four orders of magnitude greater than the Oregon water quality criterion for human health (0.0000064 µg/L), although below the chronic Oregon water quality criterion for aquatic life (0.014 µg/L) and the MCL (0.5 µg/L) ~~at an average detection limit of 0.00125 µg/L.~~ .

~~Because of the high non-detect values, these data are not summarized in the figures.~~

~~Peristaltic samples (single-point samples) were collected and analyzed for PCB Aroclors during Round 2A low- flow conditions only (i.e., November 2004, March 2005, and July 2005). Total Aroclor concentrations ranged from below detection limits (0.0025- 0.0027 U µg/L) to 0.015 µg/L.~~ Detections of PCB Aroclors were limited to six single-point samples collected during the Round 2A low flow event at the following stations:

- W001 (RM 2.0E),
- W004 (RM 3.7E-head of International Slip),
- W014 (RM 6.9E) and

[10] Only the column of the XAD sample collected during July 2005 low flow event was analyzed for total PCBs; the filter was not analyzed.~~.~~

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- W022 (RM 9.7W).

Detected PCB Aroclor ~~with~~ concentrations for SP-NB samples rang~~e~~ing from 0.00592~~47~~ J µg/L to 0.014~~90592~~ J µg/L; only one SP-VI sample (W014) was detected at 0.0167~~25~~ µg/L. ~~Because of the low frequency of detection, these data are not summarized in the figures. The discussion of the extent of PCBs in the Study Area within this section~~surface water ~~is limited to detected PCB Aroclors and PCB congeners (XAD samples) because of the high frequency of non-detects for the PCB Aroclor analysis.~~

~~Dissolved and particulate PCB congener concentrations in surface water XAD columns and filters are depicted in histograms in Figures 5.3-4-210a-c through 5.3-23. The figures show the data for each of the arranged sampling conditions (high flow, low flow, and storm water-influenced flow) arranged by river mile and sampling conditions (high-flow, low-flow, and stormwater-influenced by; Figures 5.3-20 and 5.3-21) or channel position (west and east channel and transect locations, Figures 5.3-22 and 5.3-23). Figures 5.3-21 and 5.3-23 are scaled versions of Figure 5.3-20 and 5.3-22, respectively, showing details of lower concentrations. Each of the histograms presents the particulate (0.5-µm filter) and dissolved (XAD column) fractions of the total concentration as stacked bar graphs.The six detected PCB Aroclor concentrations are also depicted in these figures.~~

Total PCB congener concentrations, calculated as ~~(~~the sum of the dissolved (XAD column) and particulate (XAD filter) concentrations, were detected in all samples.

~~) measured in single-point samples during low-flow conditions ranged from 375 J pg/L to 12,000 J pg/L (Station W013 at RM 6.7 collected in March 2005). Concentrations measured in transect samples during low-flow ranged from 159 J pg/L to 950 J pg/L (Station W005 at RM 4 in September 2006).Total PCB congener concentrations measured in the single-point samples during high-flow conditions ranged from 111 J pg/L to 749 J pg/L at Station W035 (RM 8.5) in January 2007. Concentrations measured in transect samples during high-flow ranged from 41.9 J pg/L to 391 J pg/L at Station W005 (RM 4) in January 2007.~~

~~A single stormwater-influenced flow event was observed and sampled in November 2006. Total PCB congener concentrations measured in single-point samples during this stormwater-influenced event ranged from 112 J pg/L to 2,590 J pg/L at Station W030 (RM 5.5). Concentrations measured in transect samples ranged from 121 J pg/L to 1,290 J pg/L at Station W025E (RM 2).~~

~~The following subsections describe observations of total PCB congener concentrations (PCBs) in the complete Round 2A and 3A data set. The spatial distribution of dissolved and particulate PCB concentrations and relationships to flow rate, TSS, and f_{oc} are described. The composition of this multi-component IC is also described. Total PCB~~

congeners were detected in all XAD filter and column samples collected during Round 2A and 3A sampling events.

5.4.7.4 PCB Spatial Distribution

The distribution of total PCB concentrations by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figures 5.3-24 and 5.3-25. (Note the symbols and colors indicate the sample type – point vs. transect – and the general flow conditions of the sampling event – low-flow, stormwater-influenced, or high-flow.) The majority of the highest total PCB concentrations (six out of seven >2,000 pg/L) were associated with single-point samples collected at RM 6.7 (Station W013) within Willamette Cove during low-flow conditions. The fourth highest single-point concentration was collected at RM 5.5 (W030 during the stormwater-influenced event). These data suggest that local PCB sources may exist in this region of the Study Area. The range of total PCB concentrations within the complete data set across the Study Area was fairly consistent between RM 11 and 2, excluding the highest single-point concentrations, and elevated concentrations near the east side of the river at RM 6.7.

Upstream of the Study Area, the total PCB concentrations at RM 11 were consistently higher than at RM 16, suggesting the existence of a source or sources between these two locations. Two of the three highest total PCB concentrations at RM 11 were from the sampling stations on the east side of the channel (Figure 5.3-21), indicating a possible source in this area. The second highest result at RM 11 was from a Round 2A vertically- and horizontally-integrated transect, and the field crew noted stormwater runoff entering the east side of the channel during collection of this sample (Jones 2007, pers. comm.). Within the Study Area, total PCB concentrations continued to increase between RM 11 and RM 4 in six of seven transect-based sampling events (the sole exception is the November 2004 low-flow sampling event). Total PCB concentrations at both RM 2 and in Multnomah Channel transects generally decreased from those at RM 4 but remained higher than those at RM 16. An exception to this was the RM 2 total PCB concentration from the November 2006 stormwater-influenced event, which was higher than other transect concentrations measured in that event.

The dissolved and particulate fractions of total PCBs are presented by river mile on Figures 5.3-26 and 5.3-27, respectively. Figure 5.3-28 presents the particulate data with a reduced y-axis scale to better show lower-concentration data. For both dissolved and particulate data, the highest concentrations (>1,000 pg/L) were measured at RM 6.7 (Station W013) within Willamette Cove during low-flow conditions. In addition to the Willamette Cove samples, a high concentration (2,370 pg/L) dissolved PCB sample was measured during stormwater conditions at the near-surface Station W030 at RM 5.5, and a high concentration (1,120 pg/L) particulate PCB sample was measured at RM 8.3 (W018) during low flow. With the exception of these individual points, particulate PCBs were fairly consistent across the Study Area between RM 11 and 2. Dissolved PCBs appear to increase somewhat from RM 11 downstream to RM 2 during the stormwater sampling event; low-flow and high-flow dissolved samples cover constant

~~ranges across the Study Area. Finally, upstream of the Study Area, the particulate and dissolved concentrations in RM 11 EDI and east channel samples were higher than concentrations measured at RM 16, again suggesting the existence of a source or sources between these two locations.~~

~~Line plots of total, particulate, and dissolved PCBs measured at transect stations are presented on Figures 5.3-29 through 5.3-31. These figures support the suggestion of a possible source driving increased concentrations from RM 16 to 11. Total and particulate concentrations also show a sharp decline at the RM 2 downstream transect; dissolved concentrations remained fairly constant across the site and did not decrease at RM 2. These observations are consistent with expected settling of suspended particles at the downstream end of the Study Area where the river velocity decreases.~~

~~5.4.7.9~~5.4.4.2 PCB Relationships to River Flow ~~Rate~~ Conditions

Total PCB concentrations in samples collected during low flow conditions ranged as follows:

- SP-NS: Not sampled;
- SP-NB: 0.000375 J µg/L to 0.01198 J µg/L;
- T-VI: 0.000174 J µg/L to 0.000950 J µg/L (station W023E at RM 11);
- T-EDI/NS: 0.000159 J µg/L to 0.000682 J µg/L (station W011 at RM 6.3);
- T-EDI/NB: 0.000174 J µg/L to 0.000950 J µg/L (station W005 at RM 3.9); and
- T-EDI/VI: 0.000171 J µg/L to 0.000608 J µg/L (station W023 at RM 11).

Total PCB concentrations in samples collected during storm water-influenced flow conditions ranged as follows:

- SP-NS: 0.000182 J µg/L to 0.002586 J µg/L (station W030 at RM 5.5E);
- SP-NB: 0.000112 J µg/L to 0.000897 J µg/L (station W026 at RM 2.1E);
- T-VI: 0.000121 J µg/L to 0.001290 J µg/L (station W025 at RM 2E);
- T-EDI/NS: 0.000149 J µg/L to 0.000458 J µg/L (station W005 at RM 3.9);
- T-EDI/NB: 0.000205 J µg/L to 0.000440 J µg/L (station W005 at RM 3.9); and
- T-EDI/VI: Not sampled.

Total PCB concentrations in samples collected during high flow conditions ranged as follows:

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- SP-NS: 0.000111 J µg/L to 0.000932 J µg/L (station W029 at RM 4.4W);
- SP-NB: 0.000149 J µg/L to 0.000773 J µg/L (station W035 in Swan Island Lagoon);
- T-VI: 0.000042 J µg/L to 0.000169 J µg/L (station W023 at RM 11E);
- T-EDI/NS: 0.000132 J µg/L to 0.000250 J µg/L (station W027 in Multnomah Channel);
- T-EDI/NB: 0.000205 J µg/L to 0.000391 J µg/L (station W005 at RM 3.9); and
- T-EDI/VI: Not sampled.

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~~Total PCB concentrations as a function of flow rate are presented in Figures 5.3-32 and 5.3-33. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event. Twelve concentrations above 1,000 pg/L were associated with samples collected during low-flow events.~~ PCB concentrations were consistently lower in high- flow samples ~~as~~ compared to the low- flow and storm water-influenced flow samples, suggesting that inflow concentrations at high flow rates overwhelm local effects and ~~control~~ PCB concentrations ~~until flow rates subside~~.

It is apparent that there is a source of PCBs in the Downtown Reach (between RM 11 and RM 16), since all sample events show the concentrations at the RM 11 transect are consistently greater than RM 16 transect. During three of the four low flow sampling events (March 2005, July 2005, and September 2006), there is indication that sources of PCBs are located between RM 11 and RM 6. However, the November 2004 low flow event did not show this same trend. Two of the low flow events (July 2005 and September 2006) indicate that there is also a source between RM 6 and RM 4 that sustains the elevated concentrations.

The February 2007 high flow sampling event indicates that there is a source of PCBs between RM 6 and RM 4. This source is also apparent in the November 2006 storm water-influenced flow event. Only the storm water-influenced flow indicates that there is a source of PCBs between RM 4 and RM 2.~~No concentrations above 1,000 pg/L were observed at flows of 60,000 cfs and concentrations were below 210 pg/L for the 160,000 cfs event.~~

~~Figures 5.3-34 and 5.3-35 show the dissolved and particulate fractions of total PCBs plotted against flow rate. Figure 5.3-36 presents the particulate data with a reduced y-axis scale to better show lower-concentration data. Similar to total PCBs, all of the particulate and dissolved samples with concentrations >1,000 pg/L were collected during low-flow conditions, with the exception of a single dissolved sample collected during the stormwater-influenced sampling event. For the particulate fraction, low-flow~~

samples cover a greater concentration range as compared to the high-flow and stormwater-influenced samples. For the dissolved fraction of total PCBs, low-flow and stormwater-influenced samples cover similar concentration ranges, while high-flow exhibit generally lower concentrations.

Two of the three highest total PCB concentrations at RM 11 were from the sampling stations on the east side of the channel (Figure 5.4-10), indicating possible sources in this location of the river. The second highest result at RM 11 was from a Round 2A vertically- and horizontally-integrated transect, and the field crew noted storm water runoff entering the east side of the channel during collection of this sample (Jones 2007, pers. comm.).

5.4.7.10 Distribution between PCB Dissolved and Particulate Fractions

The following subsections describe the observed trending of dissolved and particulate fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS. This analysis was specific to total PCBs and, therefore, does not extend to individual congener analysis. However, Section 5.3.6.4 provides a discussion of PCB composition (i.e., homologs) and observed patterns, which may assist with the identification of observed PCBs in the Study Area.

5.4.7.10.1 PCB Particulate and Dissolved Concentrations

Figures 5.3-37 and 5.3-38 present a scatter plot of total PCB dissolved and particulate concentration pairs. Linear regression lines are shown for the high-flow, low-flow, and stormwater-influenced sets of transect and point data. The PCB concentrations of the particulate (filter) and dissolved (column) fractions of each sample are shown on histogram Figures 5.3-20 through 5.3-23.

As seen on the scatter plots, samples with concentrations less than 500 pg/L particulate and less than 500 pg/L dissolved showed a fairly consistent trend in particulate/dissolved ratios, whereas the particulate/dissolved ratio varies substantially for high-concentration samples. In particular, low-flow point samples collected at the upper end of the dissolved concentration range (>500 pg/L) had a higher particulate component. Stormwater-influenced point samples collected at the upper end of the dissolved concentration range had the lowest particulate component.

The high-flow samples (both point and transect) tend to show lower dissolved concentrations for the given particulate concentration (or conversely, higher particulate concentrations for the given dissolved concentrations), relative to the stormwater and low-flow samples. This suggests a different character/source of PCB contaminated sediment and/or suspended solids concentration and character during high-flow events. The following section further investigates differences in the suspended solids concentration and character.

The transect sample collected at RM 11 during the low-flow event in November 2004, exhibited a high particulate to dissolved ratio. As noted previously, during collection of

this sample, the field crews observed runoff from a nearby storm drain, which may have contributed to this result.

5.4.7.10.2 PCB Associations with Suspended Solids

The associations of PCBs with suspended solids and apparent partitioning were evaluated from the surface water data set. Total PCB concentrations as a function of TSS are presented in Figures 5.3-39 and 5.3-40. High-flow samples (single-point and transect) exhibited the widest range and highest concentrations of TSS but the lowest PCB concentrations. Conversely, the remaining samples exhibited a wide range in concentration over a small range in TSS. As stated above, the high-flow samples also exhibited a lower dissolved/particulate concentration ratio relative to the stormwater-influenced and low-flow samples.

Particulate total PCB concentrations and POC (TOC–DOC) concentrations are compared in Figures 5.3-41 and 5.3-42. The high-flow samples (single-point and transect) exhibited relatively low PCB concentrations for the corresponding POC associated with the solids. The low POC values are consistent with the lower f_{oc} associated with TSS observed in high-flow samples, as shown on Figure 5.3-19. As discussed in Section 5.3.6.2, this observation may suggest the introduction of suspended particles with low organic carbon content during high-flow events. Further, the solids that become suspended in the water column during high-flow events may have a different character (low f_{oc} and low PCB concentrations) than those introduced during low-flow or stormwater-influenced events. The single-point samples characterized by high concentrations of PCBs (RM 5.5, 6.9, 8.3, and 11) did not have corresponding high TSS concentrations from the same events (Figures 5.3-39 and 5.3-40). However, these samples did exhibit high particulate-phase PCB concentrations as a function of POC (Figures 5.3-41 and 5.3-42), reflecting a higher f_{oc}.

Total PCB congener concentrations measured in the single-point samples during high-flow conditions ranged from 111 J pg/L to 749 J pg/L at Station W035 (RM 8.5) in January 2007. Concentrations measured in transect samples during high-flow ranged from 41.9 J pg/L to 391 J pg/L at Station W005 (RM 4) in January 2007.

A single stormwater-influenced flow event was observed and sampled in November 2006. Total PCB congener concentrations measured in single-point samples during this stormwater-influenced event ranged from 112 J pg/L to 2,590 J pg/L at Station W030 (RM 5.5). Concentrations measured in transect samples ranged from 121 J pg/L to 1,290 J pg/L at Station W025E (RM 2).

The following subsections describe observations of total PCB congener concentrations (PCBs) in the complete Round 2A and 3A data set. The spatial distribution of dissolved and particulate PCB concentrations and relationships to flow rate, TSS, and f_{oc} are described. The composition of this multi-component IC is also described. Total PCB

~~congeners were detected in all XAD filter and column samples collected during Round 2A and 3A sampling events.~~

5.4.4.3 ~~PCB~~ Spatial Distribution of PCBs

~~The distribution of total PCB concentrations by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figures 5.43-12a24 and 5.43-1225b. (Note the symbols and colors indicate the sample type – point vs. transect – and the general flow conditions of the sampling event – low-flow, stormwater-influenced, or high-flow.) Dissolved and particulate PCB congener concentrations in surface water XAD columns and filters and PCB Aroclor concentrations from the peristaltic pumps are depicted in histograms by flow event and by channel position (Figures 5.4-10 and 5.4-11).~~

None of the sample results exceeds the MCL for PCBs (0.5 µg/L). Results from two sample stations exceeded the chronic AWQC for aquatic life (0.014 µg/L): W004 (RM 3.7 at the head of International Slip) and W014 (RM 6.9E in Willamette Cove). All the sample results exceed the AWQC for human health (0.0000064 µg/L) by one to four orders of magnitude. The majority of the highest total PCB concentrations (~~six out of seven~~ >~~2,000~~0.001 µ~~p~~g/L) were associated with single-point samples collected ~~at RM 6.7 (Station W013) within Willamette Cove~~ during low flow conditions.

The highest concentrations (>0.01 µg/L) were collected at the following stations:

- W004 (RM 3.7E at the head of International Slip),
- W013 and W014 (RM 6.9E in Willamette Cove).

The next highest concentrations (<0.01>0.001 µg/L) were ~~fourth highest single-point concentration was~~ collected at the following stations during low flow conditions:

- W001 (RM 2.0E),
- W015 (RM 6.9W),
- W016 (RM 7.2W),
- W018 (in Swan Island Lagoon),
- W019 (RM 8.6W), and
- W020 (RM 9.7W)

~~during low flow conditions~~ and during the storm water-influenced flow event at the following stations:

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- W025 (RM 2.0E),
- W028 (RM 3.6E), and
- W030 (RM 5.5) ~~(W030 during the stormwater-influenced flow event).~~

-These data suggest that local PCB sources may exist in these~~is~~ regions of the Study Area. ~~The range of total PCB concentrations within the complete data set across the Study Area was fairly consistent between RM 11 and 2, excluding the highest single-point concentrations, and elevated concentrations near the east side of the river at RM 6.7.~~

~~Upstream of the Study Area, tThe total PCB concentrations at RM 11 were consistently higher than at RM 16, suggesting the existence of a source or sources between these two locations. Two of the three highest total PCB concentrations at RM 11 were from the sampling stations on the east side of the channel (Figure 5.43-1021), indicating a possible sources in this areareach of the river. The second highest result at RM 11 was from a Round 2A vertically- and horizontally-integrated transect, and the field crew noted stormwater runoff entering the east side of the channel during collection of this sample (Jones 2007, pers. comm.). Within the Study Area, total PCB concentrations continued to increase between RM 11 and RM 4 in six of seven transect-based sampling events (the sole exception is the November 2004 low-flow sampling event). Total PCB concentrations at both RM 2 and in Multnomah Channel transects generally decreased from those at RM 4 but remained higher than those at RM 16. An exception to this was the RM 2 total PCB concentration from the November 2006 stormwater-influenced event, which was higher than other transect concentrations measured in that event.~~

~~The dissolved and particulate fractions of total PCBs are presented by river mile on Figures 5.3-26 and 5.3-27, respectively. Figure 5.3-28 presents the particulate data with a reduced y-axis scale to better show lower-concentration data. For both dissolved and particulate data, the highest concentrations (>1,000 pg/L) were measured at RM 6.7 (Station W013) within Willamette Cove during low-flow conditions. In addition to the Willamette Cove samples, a high concentration (2,370 pg/L) dissolved PCB sample was measured during stormwater conditions at the near-surface Station W030 at RM 5.5, and a high concentration (1,120 pg/L) particulate PCB sample was measured at RM 8.3 (W018) during low flow. With the exception of these individual points, particulate PCBs were fairly consistent across the Study Area between RM 11 and 2. Dissolved PCBs appear to increase somewhat from RM 11 downstream to RM 2 during the stormwater sampling event; low-flow and high-flow dissolved samples cover constant ranges across the Study Area. Finally, upstream of the Study Area, the particulate and dissolved concentrations in RM 11 EDI and east-channel samples were higher than concentrations measured at RM 16, again suggesting the existence of a source or sources between these two locations.~~

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Line plots of total, particulate, and dissolved PCBs measured at transect stations are presented on Figures 5.3-29 through 5.3-31. These figures support the suggestion of a possible source driving increased concentrations from RM 16 to 11. Total and particulate concentrations also show a sharp decline at the RM 2 downstream transect; dissolved concentrations remained fairly constant across the site and did not decrease at RM 2. These observations are consistent with expected settling of suspended particles at the downstream end of the Study Area where the river velocity decreases.

5.4.7.11 PCB Patterns and Trends

The patterns and trends of PCB homologs in surface water XAD column and filter samples are discussed below. PCB homologs are described in Section 5.1.5. Stacked bar graphs depicting the PCB homolog distributions in the surface water dissolved (XAD column) and particulate (XAD filter) samples by flow condition and river mile are presented in Figures 5.3-43 and 5.3-44. The discussion of patterns and trends in the PCB homologs is qualitative based on visual examinations of the stacked bar graphs.

The PCB composition of the particulate fraction generally exhibited a more highly chlorinated pattern than the PCBs in the dissolved phase. Several November 2006 stormwater-influenced samples, which exhibited greater contributions from monoCBs and/or diCBs than other particulate samples and their dissolved counterparts, were exceptions to this pattern. This PCB distribution reflects the greater solubility and lower partitioning coefficients of the less-chlorinated congeners, as described in Section 6.

The PCB composition was generally similar in the dissolved fractions of the four Study Area transect locations and the downstream transect (Station W027, Multnomah Channel) during all sampling events. The dissolved PCBs at the transect locations generally consisted of a fairly equal mixture of diCBs, triCBs, tetraCBs, and pentaCBs, with contributions from hexaCBs. The sample from transect W005 (RM 4) collected during the January 2006 high-flow event had a high percentage of tetraCBs and no diCBs. However, this sample had a relatively low total PCB congener concentration (73 pg/L), and therefore, this homolog distribution may be reflective of this low concentration.

Generally, the PCB compositions in the dissolved fraction of the upstream transect (W024, RM 16) exhibited a less chlorinated pattern than the PCBs in the Study Area transect samples. The samples from the low-flow events collected at Station W024 had high proportions of diCBs. Conversely, the sample from this station collected during the January 2007 high-flow event was characterized by a high proportion of monoCBs. The PCB homolog patterns in stormwater-influenced samples collected from W024 were similar to stormwater-influenced samples from the Study Area.

The more highly chlorinated PCB composition of the particulate fractions of the transect locations is reflected in the predominance of tetraCBs, pentaCBs, hexaCBs, and heptaCBs, with spatial variations in the proportions of each homolog present. The PCBs

at transects W023 (RM 11) in November 2004 (low-flow), from W023E in September 2006, and the NB sample from W005 (RM 4) in January 2007 (high-flow) contained higher proportions of hexaCBs and heptaCBs than samples collected during other events. The sample from transect W025E (RM 2) collected during the November 2006 stormwater-influenced event contained a higher proportion of triCBs than samples from other events. The W023 (RM 11) sample collected during the November 2004 low-flow event may have been influenced by stormwater discharges from a nearby outfall (OF-45) due to a relatively heavy rainfall event (0.37 inches) on the day the sample was collected (Integral 2006a); however, the September 2006 low-flow sample from the east side of this transect had a higher total PCB concentration and a similar PCB composition to the November 2004 sample. No stormwater discharges were noted during the collection of the September 2006 sample. The interpretation of these surface water samples may be confounded by maintenance dredging conducted at Glacier's docking facility located at RM 11.3. Glacier apparently conducted dredging following approval in June 2004 by the USACE. Attempts by the LWG to obtain post-dredging information have not been successful.

The PCB composition of particulate fractions of the upstream transect Station W024 (RM 16) generally exhibited a less chlorinated pattern than the PCBs in the Study Area transect samples upstream of RM 2 for the low- and high-flow sampling events. The stormwater-influenced (September 2006) NB sample at this station had a similar PCB composition to the Study Area transect profiles, while the NS transect from this event exhibited the same less-chlorinated pattern observed at this station during the other sampling events.

The particulate fractions of the Multnomah Channel transect, Station W027, exhibited PCB profiles similar to that of the Study Area transect stations during the high- and low-flow sampling events. The PCB profile at Station W027 during the September 2006 stormwater-influenced event was similar to the profiles of the west and mid-channel samples from transect W025 (RM 2) collected during the same event, exhibiting a more highly chlorinated PCB profile. The east sample from transect W025 exhibited a less chlorinated PCB profile than other transect stations during the stormwater-influenced event. PCB patterns in several other samples from location W025 were also less chlorinated than other Study Area transect samples.

Several of the single-point particulate fraction samples from the November 2006 stormwater-influenced sampling contained unusually high proportions of the less chlorinated homolog groups in comparison to the other sampling events. At Station W037 (RM 9.6, west bank), the NB sample had a higher proportion of diCBs and the NS sample had higher proportions of monoCBs and diCBs. Similarly, the Station W038 (RM 9.9, east bank) NB sample had higher proportions of monoCBs and diCBs. Higher proportions of monoCBs and diCBs were observed in the NS sample at Station W031 (RM 6.1) and in the NB sample at Station W028 (RM 3.6). The dissolved fractions of these samples had a similar homolog distribution to the other samples from these locations. MonoCBs accounted for 91 percent of PCBs in the dissolved fraction of the

~~NS sample at Station W030 (RM 5.5). This sample had a high total PCB congener concentration (2,370 J pg/L). With the exception of Station W037 (RM 9.6), the corresponding NS or NB samples did not exhibit similar distributions. These findings would point to a stormwater-related source of monoCBs and diCBs near these locations.~~

~~The PCB homolog composition in samples from the NS and NB locations differed from that of the transect samples to varying degrees, likely reflecting local sediment conditions or upland sources. With the exceptions mentioned above, the NS and NB samples exhibited similar PCB distributions at both the NB/NS transect and single-point stations. The PCBs in Swan Island Lagoon, Stations W018 (RM 8.3) and W035 (RM 8.5), were slightly more chlorinated overall than PCBs in the transect samples and the sampling locations in the main river channel, with the exception of particulate fractions from Willamette Cove (Station W013, RM 6.7) and Station W029 (RM 4.4), both of which are discussed below. The predominant homolog groups in this area are pentaCBs, hexaCB, and heptaCBs.~~

~~At Station W015 (RM 6.9) on the west bank, the abundance of tetraCBs was generally slightly less than at Station W016, located less than half a mile upstream. However, in November 2004, the triCBs were unusually abundant at this station in both the particulate and dissolved fractions. The total PCB congener concentration in the November 2004 sample was also unusually high (1,290 pg/L in the particulate fraction and 639 J pg/L in the dissolved fraction). The PCB concentration and homolog profiles imply contributions from an additional source or sources in November 2004. Because rainfall of 0.24 inches was recorded on this sampling date (Integral 2006a), a source or sources related to stormwater discharge near this sampling location is possible.~~

~~In Willamette Cove, Station W013 (RM 6.7) east bank, the total PCB concentration was high relative to other areas (maximum of 9,560 J pg/L for particulate PCBs and 2,420 J pg/L for dissolved PCBs). The PCB profile in the particulate fraction was more chlorinated than other areas, dominated by hexaCBs and heptaCBs. The dissolved PCB profile was similar to that of the transect samples.~~

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5.4.5 Total PCDD/Fs and TCDD TEQ in Surface Water

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Total PCDD/F and TCDD TEQ data are summarized in Tables 5.4-6 through 5.4-11. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-8, and 5.4-10. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and 5.4-11a-d. All PCDD/F and TCDD TEQ surface water sample results are presented in Tables 5.4-13 and 5.4-14 by sample event and sample ID number.

Dissolved and particulate PCDD/F congener concentrations in surface water XAD columns and filters and concentrations from the peristaltic pump samples are presented in stacked bar graphs by flow event and by river mile/channel position on Figures 5.4-14 and 5.4-15. Dissolved and particulate TCDD TEQ concentrations in surface water are presented similarly on Figures 5.4-18 and 5.4-19.

Total PCDD/F concentrations at the transect locations as a function of flow rate is presented on Figure 5.4-16. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

~~**5.4.8**~~ Figure 5.4-17 presents a scatter plot of all Total PCDD/F surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm-water-influenced, or high flow).

5.4.5.1 Total PCDD/Fs and TCDD TEQ Data

5.4.5.1.1 Total PCDD/Fs Data

Total PCDD/Fs were analyzed as PCDD/F congeners in ~~H~~high-volume surface water samples ~~were analyzed for PCDD/Fs~~ by HRGC/HRMS in 77 of the total 123 XAD samples collected; 7 SP-NS samples, 16 SP-NB samples, 11 transect EDI-VI samples, 18 SP-VI samples, 13 transect EDI-NS samples, and 12 transect EDI-NB samples. ~~Stacked bar graphs depicting Total PCDD/F concentrations in the surface water dissolved (XAD column) and particulate (XAD filter) samples by flow condition and river mile are presented in Figures 5.4-14 and 5.4-15.~~

Total PCDD/F congener concentrations, calculated as the sum of the dissolved (XAD column) and particulate (XAD filter) concentrations, were detected in all samples.

5.4.5.1.2 TCDD TEQ Data

TCDD TEQ were calculated in 77 of the total 123 XAD samples collected; 7 SP-NS samples, 16 SP-NB samples, 11 transect EDI-VI samples, 18 SP-VI samples, 13 transect EDI-NS samples, and 12 transect EDI-NB samples. Stacked bar graphs depicting TCDD TEQ concentrations in the surface water dissolved (XAD column) and particulate (XAD filter) samples by flow condition and river mile are presented on Figures 5.4-18 and 5.4-19.

TCDD TEQ concentrations, calculated as the sum of the dissolved (XAD column) and particulate (XAD filter) TCDD toxicity equivalent concentrations of each dioxin/furan congener, were detected in all samples.

5.4.5.2 PCDD/F and TCDD TEQ Relationships to River Flow ~~Rate~~Conditions

5.4.5.2.1 PCDD/F Relationship to River Flow ~~Rate~~Conditions

Total PCDD/F concentrations in samples collected during low flow conditions ranged as follows:

- SP-NS: Not sampled;
- SP-NB: 0.000031 µg/L to 0.000162 µg/L (station W013 at RM 6.9E);
- T-VI: 0.000006 J µg/L to 0.000027 J µg/L (station W023E at RM 11);

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- T-EDI/NS: 0.000018 J µg/L to 0.000026 J µg/L (station W027 in Multnomah Channel);
- T-EDI/NB: 0.000028 J µg/L to 0.000052 J µg/L (station W005 at RM 3.9); and
- T-EDI/VI: 0.000017 J µg/L to 0.000050 J µg/L (station W005 at RM 3.9).

Total PCDD/F concentrations in samples collected during storm water-influenced flow conditions ranged as follows:

- SP-NS: 0.000038 J µg/L to 0.000054 J µg/L (station W035 in Swan Island Lagoon)
- SP-NB: 0.000036 µg/L to 0.000055 J µg/L (station W032 at RM 6.9E);
- T-VI: 0.000004 J µg/L to 0.000118 µg/L (station W023 at RM 11E);
- T-EDI/NS: 0.000019 J µg/L to 0.000028 µg/L (station W005 at RM 3.9);
- T-EDI/NB: 0.000026 µg/L to 0.000050 µg/L (station W005 at RM 3.9); and
- T-EDI/VI: Not sampled.

Total PCDD/F concentrations in samples collected during high flow conditions ranged as follows:

- SP-NS: 0.000025 µg/L to 0.000074 µg/L (station W035 in Swan Island Lagoon);
- SP-NB: 0.000027 J µg/L to 0.000075 µg/L (station W035 in Swan Island Lagoon);
- T-VI: 0.000005 J µg/L to 0.000031 J µg/L (station W023 at RM 11E);
- T-EDI/NS: 0.000010 J µg/L to 0.000030 J µg/L (station W027 in Multnomah Channel and station W024 at RM 16);
- T-EDI/NB: 0.000008 J µg/L to 0.000029 µg/L (station W027 in Multnomah Channel); and
- T-EDI/VI: Not sampled.

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~~Total PCDD/F concentrations as a function of flow rate are presented in Figure 5.43-1649. Two of the three highest concentrations were measured in single-point samples during low-flow conditions.~~ Figure 5.4-16~~The~~ shows that the concentrations are overwhelmed by localized affects and the ~~second highest concentration was measured~~

~~in a transect sample on the east side of the river at RM 11 during the stormwater-influenced event. However, excluding these high-concentration samples, the~~re does not appear to be an overall trend ~~towards~~between ~~high-~~total PCDD/F values ~~associated~~and ~~with low-~~flow conditions. ~~-~~It is apparent that there is a source of PCDD/Fs in the Downtown Reach (between RM 11 and RM 16), since all sample events show the concentrations at the RM 11 transect are consistently greater than concentrations at the RM 16 transect. During three of the four low flow sampling events (March 2005, July 2005, and September 2006), there is indication that sources of PCDD/Fs are located between RM 11 and RM 6.3. The July 2005 low flow event indicates that there is also a source between RM 6.3 and RM 3.9 that greatly increases the PCDD/Fs concentrations. The storm water-influenced flow indicates that there is a source of PCDD/Fs between RM 3.9 and RM 2; the February 2007 high flow event shows a similar pattern. Concentrations of PCDD/Fs leaving the Study Area in Multnomah Channel were consistently higher than RM 16 upstream of the Study Area, while concentrations at RM 2 were consistently lower than RM 16 and Multnomah Channel.

5.4.5.2.2 TCDD TEQ Relationship to River Flow ~~Rate~~Conditions

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TCDD TEQ concentrations in samples collected during low flow conditions ranged as follows:

- SP-NS: Not sampled;
- SP-NB: 1.1×10^{-7} µg/L to 9.17×10^{-7} µg/L (station W013 at RM 6.9E);
- T-VI: 1.81×10^{-8} J µg/L to 6.43×10^{-8} J µg/L (station W023E at RM 11);
- T-EDI/NS: 2.69×10^{-8} J µg/L to 9.17×10^{-8} J µg/L (station W027 in Multnomah Channel);
- T-EDI/NB: 9.28×10^{-8} J µg/L to 1.97×10^{-7} J µg/L (station W005 at RM 3.9); and
- T-EDI/VI: 4.3×10^{-8} J µg/L to 3.27×10^{-7} J µg/L (station W005 at RM 3.9).

TCDD TEQ concentrations in samples collected during storm water-influenced flow conditions ranged as follows:

- SP-NS: 7.77×10^{-8} J µg/L to 1.36×10^{-7} J µg/L (station W023 in Swan Island Lagoon);
- SP-NB: 1.01×10^{-7} µg/L to 2.12×10^{-7} J µg/L (station W033 at RM 7W);
- T-VI: 9.55×10^{-9} J µg/L to 2.78×10^{-7} µg/L (station W023 at RM 11E);
- T-EDI/NS: 3.73×10^{-8} J µg/L to 7.29×10^{-7} µg/L (station W027 in Multnomah Channel);

- T-EDI/NB: 8.9×10^{-8} µg/L to 1.09×10^{-7} µg/L (station W027 in Multnomah Channel);
- T-EDI/VI: Not sampled.

Total PCDD/F concentrations in samples collected during high flow conditions ranged as follows:

- SP-NS: 5.09×10^{-8} µg/L to 1.68×10^{-7} µg/L (station W035 in Swan Island Lagoon);
- SP-NB: 4.91×10^{-8} J µg/L to 1.49×10^{-7} µg/L (station W035 in Swan Island Lagoon);
- T-VI: 1.13×10^{-8} J µg/L to 6.57×10^{-8} J µg/L (station W023 at RM 11E);
- T-EDI/NS: 2.38×10^{-8} J µg/L to 6.73×10^{-8} J µg/L (station W027 in Multnomah Channel);
- T-EDI/NB: 1.65×10^{-8} J µg/L to 6.82×10^{-8} µg/L (station W005 at RM 3.9); and
- T-EDI/VI: Not sampled.

~~**At the downstream end of the Study Area, the low-flow sample concentration ranges decreased relative to ranges observed within the Study Area.Concentrations of PCDD/Fs in surface water XAD column and filter samples are depicted in Figure 5.3-45. Dissolved and particulate PCDD/F congener concentrations in surface water XAD columns and filters are depicted as a histogram with data arranged by river mile and sampling conditions (high-flow, low-flow, and stormwater-influenced). Figure 5.3-46 presents the same data as a histogram sorted by channel position (west and east channel and transect locations). Each of the histograms presents the particulate (0.5-µm filter) and dissolved (XAD column) fractions of the total concentration as stacked bar graphs.**~~

~~**Total PCDD/Fs (dissolved plus particulate concentrations) measured in single-point samples collected during low-flow conditions ranged from 30.7 pg/L to 162 pg/L at Station W013 (RM 6.7) collected in July 2005. Concentrations measured in transect samples collected during low-flow conditions ranged from 5.9 J pg/L to 51.6 J pg/L at Station W005 (RM 4) in September 2006.**~~

~~**Total PCDD/Fs measured in single-point samples collected during high-flow conditions ranged from 24.7 pg/L to 74.9 pg/L at Station W035 (RM 8.5) in January 2007. Concentrations measured in transect samples collected during high-flow conditions ranged from 5.3 J pg/L to 44.0 pg/L (Station W005 at RM 4 in January 2006).**~~

~~**Total PCDD/Fs measured during the stormwater-influenced event (November 2006) ranged from 36.0 pg/L to 55.2 J pg/L (Station W032 at RM 6.7) in single-point samples and 5.5 J pg/L to 118 pg/L (Station W023E) at RM 11 in transect samples.**~~

~~**The following subsections describe observations of total PCDD/Fs congener concentrations. The spatial distribution of dissolved and particulate concentrations and relationships to flow rate, TSS, and f_{oc}, as well as the composition of this multi-component IC are described. Total PCDD/Fs were detected in all XAD filter and column samples collected during Round 2A and 3A sampling events.**~~

~~5.4.8.1~~5.4.5.3 ~~PCDD/F and TCDD TEQ~~ Spatial Distribution of PCDD/F and TCDD TEQ

There are no ~~ambient water criteria~~AWQC for total PCDD/F. None of the sample results exceed the MCL for TCDD TEQ ($3x10^{-5}$ µg/L) or the chronic AWQC for aquatic life ($3.8x10^{-4}$ µg/L). All the sample results exceed the AWQC for human health ($5.1x10^{-10}$ µg/L) by one to three orders of magnitude. The majority of the highest total concentrations (>$1x10^{-7}$ µg/L) were associated with both transect and single-point samples collected predominantly during low flow and storm water-induced flow conditions.

The highest concentrations were collected at the following stations during low flow events:

- W005 (transect at RM 3.9),
- W011 (transect at RM 6.3),
- W013 (RM 6.9E), and
- W015 (RM 6.9W)

and during the storm water-influenced flow event at the following stations:

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- W005 (transect at RM 3.9),
- W023 (RM 11E),
- W027 (transect in Multnomah Channel),
- W032 (RM 6.9E),
- W033 (RM 7.0W), and
- W035 (Swan Island Lagoon).

The only sample with a high concentration collected during high flow events was in Swan Island Lagoon.These data suggest that local PCDD/F sources may exist in these regions of the Study Area. ~~The distribution of total PCDD/F concentrations (dissolved plus particulate concentrations) by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figure 5.3-47. The highest concentration (162 pg/L) was measured in the single-point sample collected at RM 6.7 (Station W013) during the July 2005 low-flow sampling event. The concentration measured in the field replicate from this location (30.8 pg/L) collected the following day was much lower. The second highest PCDD/F concentration (118 pg/L) was measured in the transect sample from RM 11 on the east side of the river (Station W023E), collected during the stormwater-influenced event (November 2006). This value is more than twice the concentration of the other samples collected at RM 11, which were all less than 40 pg/L. This observation may indicate the presence of a localized PCDD/F source or sources within this area.~~

~~The next highest concentrations were measured at RM 6.9 (third highest concentration; Station W015) and RM 8.5 (fourth and fifth highest concentrations; Station W035). The distribution of PCDD/Fs throughout the Study Area and upstream to RM 16 did not vary greatly, with the exception of the five highest concentrations. The lowest concentrations were generally measured at RM 2 (Figures 5.3-45 and 5.3-46).~~

~~At the downstream end of the Study Area total PCDD/F concentrations in Multnomah Channel were generally higher than those at RM 16 while total PCDD/F concentrations at RM 2 were generally lower than those at RM 16 (Figure 5.3-48). From sampling event to sampling event, total PCDD/F concentrations within the Study Area were variable and did not display consistent trends from upstream to downstream.~~

~~5.4.8.2 PCDD/F Relationships to Flow Rate~~

~~Total PCDD/F concentrations as a function of flow rate are presented in Figure 5.3-49. Two of the three highest concentrations were measured in single-point samples during low-flow conditions. The second highest concentration was measured in a transect sample on the east side of the river at RM 11 during the stormwater-influenced event. However, excluding these high-concentration samples, there does not appear to be a~~

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trend towards high total PCDD/F values associated with low-flow conditions. At the downstream end of the Study Area, the low-flow sample concentration ranges decreased relative to ranges observed within the Study Area.

5.4.8.3 Distribution between PCDD/F Dissolved and Particulate Fractions

The following subsections describe the observed trending of dissolved and particulate fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS. This analysis was specific to total PCDD/Fs and therefore does not extend to individual dioxins and furans. However, Section 5.3.7.4 provides a discussion of PCDD/F composition and patterns, which may assist with the identification of observed concentrations in the Study Area.

5.4.8.3.1 PCDD/F Dissolved and Particulate Concentrations

The dissolved (XAD column) and particulate (XAD filter) fractions of total PCDD/F concentrations for each surface water sample are presented as histograms by flow event type on Figure 5.3-45 and by channel position on Figure 5.3-46. These figures clearly demonstrate that PCDD/Fs tend to partition to the particulate fraction in surface water within the Study Area. The extent of this tendency is presented in Figure 5.3-50, which shows a scatter plot of the dissolved vs. particulate concentrations of total PCDD/Fs. The two highest concentrations measured at RM 6.7 and 11 during low-flow and stormwater-influenced conditions, respectively, exhibit extremely high particulate to dissolved ratios (greater than an order of magnitude difference between the two phases). If these samples are excluded from the analysis, as presented in Figure 5.3-51, where the x-axis (particulate concentration) is zoomed, the tendency for partitioning into the solid phase is also apparent for low-flow and high-flow samples. However, the stormwater-influenced sample concentrations appear to be more evenly distributed within the data set.

PCDD/F Associations with Suspended Solids

The associations of total PCDD/Fs with suspended solids and apparent partitioning were evaluated from the surface water data set. Total concentrations as a function of TSS are presented in Figures 5.3-52 and 5.3-53. PCDD/F concentrations increased slightly with higher suspended solids for high-flow transect samples. However, concentrations appear to increase more rapidly with increased suspended solids for the high-flow single-point samples. The stormwater-influenced samples increased independently of suspended solids in surface water. The transect and single-point samples collected during this event were all characterized by TSS values less than 10 mg/L. The low-flow transect samples appear to have a non-linear distribution with varying TSS and PCDD/F concentrations and, therefore, do not exhibit a clear trend (Figures 5.3-52 and 5.3-53).

Particulate total PCDD/F concentrations and POC concentrations are compared in Figures 5.3-54 and 5.3-55. As with PCBs, the high-flow samples (single-point and transect) exhibited relatively low PCDD/F concentrations for the corresponding POC

associated with the solids. Conversely, the stormwater-influenced samples tended to exhibit higher POC values in relation to total PCDD/F concentrations and were associated with lower TSS (less than 10 mg/L) values. This may indicate that solids that become suspended during stormwater-influenced events may have a unique character of high f_{oc} and varying loads of PCDD/Fs. Samples characterized by high concentrations of PCDD/Fs did not have corresponding high TSS concentrations compared to other samples from the same events (Figures 5.3-52 and 5.3-53). However, these samples did exhibit a high particulate-phase PCDD/F concentration as a function of POC.

5.4.8.4 PCDD/F Patterns and Trends

Stacked bar graphs depicting the PCDD/F homolog distributions in the surface water dissolved (XAD column) and particulate (XAD filter) samples by flow condition and river mile are presented in Figures 5.3-56 and 5.3-57. The discussion of patterns and trends in the PCDD/F homologs is qualitative based on visual examinations of the stacked bar graphs.

Overall, the PCDD/F homolog profiles were dominated by OCDD and HpCDDs in both the dissolved and particulate fractions. At most transect stations and in most sampling events, OCDD constituted more than half of the PCDD/Fs in the particulate fraction, and from 30 to 95 percent of the PCDD/Fs in the dissolved fraction. HpCDDs accounted for another 15 to 30 percent of the total in both the dissolved and particulate fractions. As would be expected, the dissolved fraction generally contained a greater abundance of the less chlorinated homolog groups than the particulate fraction. The homolog pattern for the particulate fraction PCDD/Fs varied little from transect to transect and from upstream to downstream of the Study Area.

In the dissolved fraction of the transect samples, only a few samples differed from the trend of OCDD and HpCDD dominance. The NS sample from the eastern bank at transect W024 (RM 16) and the eastern bank sample from transect W025 (RM 2) from the January 2007 sampling event, and the November 2006 sample from the west bank at transect W025 exhibited high abundance of TCDDs. Two samples from the November 2006 sampling event had very low (<0.01 pg/L) total PCDD/F concentrations, and only TCDDs were detected in these samples. With these exceptions, only minor differences between the transects were observed; the low-flow sampling events exhibited higher proportions of the less chlorinated homolog groups in the dissolved fraction, and the upriver stations exhibited a less chlorinated profile than those in the Study Area.

The NS and NB transects had very similar particulate PCDD/F homolog profiles during all sampling events, with similar dissolved profiles during low-flow events. Homolog patterns in the NS samples were different than their corresponding NB samples at Stations W011 (RM 6.3) and W005 (RM 4) in the November 2006 stormwater-influenced sampling event and at Station W024 (RM 16) in the January 2007 high-flow sampling event. The NS and NB single-point samples also generally exhibited similar particulate and dissolved PCDD/F homolog profiles during all events.

~~The single-point samples from Stations W035 (RM 8.5) and W033 (RM 7) exhibited similar PCDD/F homolog profiles to the transect stations in both the dissolved and particulate fractions under high-flow and stormwater-influenced conditions. These stations were not sampled under low-flow conditions.~~

~~However, at Station W015, on the western riverbank at RM 6.9, furans were somewhat more abundant than at other locations during all sampling events, in both the dissolved and particulate fractions. The pattern of the dioxins was similar to that of the transect locations. This area may be influenced by a different PCDD/F source compared to the river as a whole.~~

~~In Willamette Cove, Stations W013 and W032 (both at RM 6.7), the profile for PCDD/Fs in the dissolved and particulate fractions generally resembled the profiles at the transect locations during each sampling event, but the particulate PCDD/F concentrations found at this location were consistently higher than at nearby transect Station W011 (RM 6.3). The PCDD/F patterns in field replicate samples LW2-W3013-2-F (particulate phase, July 2005) and LW2-W2013-2-C (dissolved phase, March 2005) included a distinctly larger fraction of dioxins and a smaller furan fraction than the respective "parent" samples and were not similar to transect Station W011. These replicate samples were collected sequentially, a day apart, and may reflect temporal differences in the PCDD/Fs in Willamette Cove.~~

~~5.4.9~~5.4.6 ~~Total~~ DDx in Surface Water

~~Total~~ DDx data ~~is~~are summarized in Table~~s~~ 5.4-~~3~~65~~.~~ through 5.4-~~8~~1120. Transect samples are summarized by flow event in Tables 5.4-~~3~~6, 5.4-~~5~~8~~11~~, and 5.4-~~7~~106~~.~~ ~~while s~~Single ~~-~~point samples are summarized by flow event in Tables 5.4-~~4~~7a-d, 5.4-9a-d and ~~through~~ 5.4-11a-d~~0 (high flow events), Tables 5.4-612 through 5.4-15 (low flow events), and Tables 5.4-817 through 5.4-20 (storm water-influenced events)~~. All DDx surface water sample results are presented in Table~~s~~ 5.4-~~12~~1526~~ through 5.4-17~~ by sample event and sample ID number.

Dissolved and particulate DDx ~~congener~~ concentrations in surface water XAD columns and filters and DDx concentrations from the peristaltic pumps are presented in stacked bar graphs by flow event on Figure~~s~~ 5.4-20~~a-c~~ and by river mile/channel position on~~in~~ Figure~~s~~ 5.4-~~10~~2121~~a-c and 5.4-11~~.

~~Total PCB~~DDx concentrations at the transect locations as a function of flow rate ~~is~~are presented on~~in~~ Figure~~s~~ 5.4-~~1~~22. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

Figures 5.4-~~1~~23a ~~and~~ -b present a scatter plot of all ~~Total PCB~~DDx surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low ~~-~~flow, storm water-influenced, or high ~~-~~flow.)

Commented [JMK9]: We have noticed what appear to be some database inconsistencies compared to LWG tables, such as sample counts, inclusion//exclusion of duplicates, etc, so it is recommended that all counts/ranges be reviewed carefully throughout. See specific examples presented in comment bubbles for Total PAHs and aldrin, which were used as examples to identify specific questions.

5.4.6.1 ~~Total~~ DDx Data

DDx contaminants were analyzed by EPA method 8081A in 79 of the total 163 peristaltic samples collected; 54 SP-NB samples, ten SP-NS samples, nine SP-VI samples, two T-NB samples, and four T-NS samples. High-volume surface water samples (XAD samples) were analyzed for DDx contaminants by AXYS Method MLA-028 (Rev 1 or 2) in 88 of the total 123 XAD samples collected; 24 SP-NB samples, nine SP-NS samples, 12 T-NB samples, 12 T-NS samples, and 31 T-VI samples.

DDx contaminants were not detected in the majority of the peristaltic samples (52 of 79 nondetect samples) with detection limits ranging from 0.000472 to 0.0015 µg/L, which is one to two orders of magnitude less than the EPA RSLs for tapwater (which range from 0.027 µg/L for DDD to 0.2 µg/L for 4-4'-DDE, and DDT). Most detection limits are also less than the chronic Oregon water quality criterion for aquatic life (0.001 µg/L for 4,4'-DDT). Only three of the 52 detection limits exceed 0.001 µg/L.

DDx contaminants were detected in all of the XAD samples (column sample or filter sample or both).

~~High-volume samples were analyzed for total DDx by HRGC/HRMS. Concentrations of total DDx in surface water XAD column and filter samples are depicted as histograms with data arranged by river mile and sampling conditions (high-flow, low-flow, and stormwater-influenced) in Figures 5.3-58 and 5.3-59. Peristaltic total DDx data are presented in Figure 5.3-60. Figure 5.3-61 through 5.3-63 present the same data as histograms sorted by channel position (west and east channel and transect locations). Each of the XAD histograms presents the particulate (0.5-µm filter) and dissolved (XAD column) fractions of the total concentration as stacked bar graphs. The peristaltic data histograms present the total (filtered plus unfiltered) fraction.~~

~~Total DDx was detected in virtually all of the XAD samples (99 percent of XAD filters and 100 percent of XAD columns) collected during Round 2A and 3A sampling events. In contrast, total DDx was detected in only 34 percent of the peristaltic samples, due to elevated detection limits based on smaller sample volumes than those collected for XAD samples.~~

~~Total DDx measured in single-point XAD samples collected during low-flow conditions ranged from 49.2 J pg/L to 9,760 pg/L (Station W016 at RM 7.2 in July 2005). Concentrations measured in transect samples collected during low-flow ranged from 42.8 J pg/L to 546 J pg/L (Station W005 at RM 4 in September 2006).~~

~~Total DDx measured in single-point XAD samples collected during high-flow conditions ranged from 266 J pg/L to 857 J pg/L (Station W031 at RM 6.1) in January 2007. Concentrations measured in transect samples collected during high-flow ranged from 162 J pg/L to 618 J pg/L (Station W023E) at RM 11 also in January 2007.~~

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Total DDx measured in single-point XAD samples collected during the stormwater-influenced event (November 2006) ranged from 76.7 J pg/L to 675 J pg/L at Station W033 (RM 7). Concentrations measured in transect samples ranged from 33.2 J pg/L to 201 J pg/L at Station W011 (RM 6.3).

Total DDx was detected in only four peristaltic samples collected from single-point stations during low-flow conditions. Concentrations ranged from 0.000693 J µg/L to 0.0187 NJ µg/L at Station W001 (RM 2 in March 2005).

Total DDx was detected in 12 of 14 single-point peristaltic samples collected during high-flow conditions. Concentrations ranged from 0.00017 J µg/L to 0.00205 NJ µg/L at Station W037 at RM 9.6 in January 2007.

Concentrations of total DDx measured in peristaltic samples during the stormwater-influenced event ranged from 0.0015 µg/L to 0.0047 NJ µg/L at Station W037 (RM 9.6).

The following subsections present observations of total DDx concentrations in the combined Round 2A and Round 3A surface water data set.

5.4.9.10 DDx Spatial Distribution

The distribution of total DDx concentrations (dissolved plus particulate concentrations) by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figures 5.3-64 and 5.3-65 (scatter plots), 5.3-66 (line plot), as well as 5.3-58 and 5.3-59 (histograms). The highest concentrations were measured in single-point samples collected during low-flow conditions near the middle of the Study Area at RM 6.9 (Station W015; 3,590 to 7,660 pg/L) and RM 7.2 (Station W016; 1,240 J to 9,760 pg/L). Excluding these higher concentrations, the overall range of observed concentrations across the Study Area and upstream to RM 16 was fairly consistent. Further, concentrations measured in the high-flow samples were generally higher than those associated with the low-flow and stormwater-influenced samples. This was especially evident at RM 11 and 16, where the high-flow concentrations were much greater than the low-flow and stormwater-influenced samples. These high-flow sample concentrations also covered a fairly consistent range across the Study Area, including RM 2.9 (Multnomah Channel) and RM 16 (Figures 5.3-58 and 5.3-59). This observation may suggest that DDx concentrations in the majority of the Study Area during high-flow are primarily controlled by upstream loading (see Section 6.1.1). Finally, the stormwater and low-flow sample concentrations covered a low range through RM 16 and 11, and increased around RM 7.5, suggesting a potential source or sources in this portion of the Study Area.

Total DDx concentrations increased from upstream (RM 16 and 11) to downstream (RM 4) in six of seven transect sampling events (Figure 5.3-66); the sole exception was the February 2007 high-flow event, during which concentrations dropped slightly from RM 11 to RM 4. Further downstream at RM 2.9 (Multnomah Channel) and RM 2,

~~transect total DDx concentrations were also generally higher than upstream transect concentrations in low-flow and stormwater-influenced conditions, but were generally lower than upstream concentrations in high-flow conditions.~~

~~5.4.9.13~~5.4.6.2 DDx Relationships to River Flow ~~Rate~~Conditions

~~Total~~ DDx concentrations are subsequently listed as measured in the peristaltic samples or calculated as the sum of the dissolved (XAD column) and particulate (XAD filter) concentrations. ~~Total~~ DDx concentrations in samples collected during low flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.00000763 J µg/L to 0.0187 J µg/L (station W001 at RM 2.0E)
- SP-NS: Not sampled
- SP-VI: Not sampled
- T-NB: 0.0000299 J µg/L to 0.000546 J µg/L (station W005 at RM 3.9)
- T-NS: 0.0000166 J µg/L to 0.0005 J µg/L (station W027 at Multnomah Channel)
- T-VI: 0.0000104 J µg/L to 0.000322 J µg/L (station W025 at RM 2W)

~~Total~~ DDx concentrations in samples collected during storm water-influenced flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.0000469 J µg/L to 0.0047 J µg/L (station W037 at RM 9.6W)
- SP-NS: 0.0000193 J µg/L to 0.0025 J µg/L (station W029 at RM 4.4W)
- SP-VI: Not sampled
- T-NB: 0.0000378 J µg/L to 0.000201 J µg/L (station W011 at RM 6.3)
- T-NS: 0.00000786 J µg/L to 0.0029 J µg/L (station W031 at RM 6.1W)
- T-VI: 0.00003 J µg/L to 0.000184 J µg/L (station W025 at RM 2W)

~~Total~~ DDx concentrations in samples collected during high flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.000119 J µg/L to 0.00205 J µg/L (station W037 at RM 9.6W)
- SP-NS: 0.000105 J µg/L to 0.00096 J µg/L (station W029 at RM 4.4W)
- SP-VI: Not sampled

- T-NB: 0.00013 J µg/L to 0.000578 J µg/L (station W005 at RM 3.9)
- T-NS: 0.000124 J µg/L to 0.000535 J µg/L (station W005 at RM 3.9)
- T-VI: 0.0000296 J µg/L to 0.000618 J µg/L (station W023 at RM 11E)

With the exception of the highest total DDx concentrations that were measured at RM 6.9 and 7.2 and a single high concentration measured at RM 2 (March 2005), the range of total DDx concentrations detected was fairly consistent. Total DDx concentrations in surface water transect stations (Figure 5.4-23a-b) were generally higher in high flow samples than in those associated with the low flow and storm water-influenced samples.~~Total DDx concentrations as a function of flow rate are presented in Figures 5.3-67 and 5.3-68. With the exception of the highest total DDx concentrations that were measured at RM 6.9 and 7.2 (as discussed above in Section 5.3.8.1), the range of concentrations was fairly consistent across all flow regimes (Figure 5.3-59). Again, this indicates that total DDx is transported from upstream sources into the Study Area during high-flow conditions. This figure does not demonstrate a clear relationship between flow rate and total DDx concentrations; however, the highest concentrations were measured during low-flow conditions (Figure 5.3-67). This may suggest the potential for localized sources within the mid-Study Area vicinity, especially near RM 6.9 and 7.2.~~

5.4.6.3 DDx Spatial Distribution

None of the samples exceed the EPA RSLs for DDx contaminants (which range from 0.027 µg/L for DDD to 0.2 µg/L for 4,4'-DDE and DDT). Results from twenty sample stations exceeded the chronic Oregon water quality criterion for aquatic life (0.001 µg/L for 4,4'-DDT) by a factor of 1 to 19.

The highest concentrations (>0.003 µg/L) were collected at the following stations during low flow events:

- W001 (RM 2.0E),
- W015 (RM 6.9W) on three dates, and
- W016 (RM 7.2W),

and during the storm water-influenced flow event at stations:

- W030 (RM 5.5E), and
- W037 (RM 9.6W).

The highest XAD concentrations were measured in single-point samples collected during low flow conditions near the middle of the Study Area at RM 6.9 (station W015;

0.00359 to 0.00766 µg/L) and RM 7.2 (station W016; 0.00124 J to 0.00976 µg/L). Excluding these higher concentrations, the overall range of observed concentrations across the Study Area and upstream to RM 16 was fairly consistent. The storm water-influenced and low flow sample concentrations covered a low range through RM 16 and 11 and increased around RM 7.5, suggesting a potential source or sources in this portion of the Study Area.

5.4.11.0 Distribution between DDx Dissolved and Particulate Fractions

The following subsections describe the observed trending of total DDx dissolved and particulate fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS. Section 5.3.8.4 provides a discussion of total DDx composition and patterns and trends, which may assist with the identification of observed concentrations in the Study Area.

5.4.13.0.0 DDx Particulate and Dissolved Concentrations

The distribution of total DDx (i.e., the sum of the dissolved and particulate concentrations) by river mile is presented on histograms by flow event type in Figures 5.3-58 and 5.3-59 and histograms by channel position in Figures 5.3-61and 5.3-62. Although these figures show distinctly high total DDx concentrations at RM 6.9 and 7.2, there does not appear to be any clear patterns in the ratio of dissolved and particulate fractions or the distribution between single-point and transect samples.

The dissolved and particulate fractions of total DDx are plotted on scatter plots in Figures 5.3-69 and 5.3-70. Linear regression lines are shown for the high-flow, low-flow, and stormwater-influenced sets of transect and point data. The single-point and transect samples collected during the high-flow events followed the general trend of the other flow types. The samples characterized by the highest dissolved concentration tended to have a higher particulate concentration.

Three samples collected at RM 2 (Station W025) had higher dissolved to particulate ratios. This may be due to the lower suspended solids load in the downstream portion of the Study Area (at RM 2) rather than an actual shift in partitioning behavior. There does not appear to be a clear distinction between low-flow and stormwater-influenced or single-point and transect samples in these figures.

5.4.17.0.0 DDx Associations with Suspended Solids

The associations of total DDx with suspended solids and apparent partitioning were evaluated from the surface water data set. Total concentrations as a function of TSS are presented in Figures 5.3-71 and 5.3-72. The high-concentration, low-flow samples exhibited the highest ratios of total DDx to TSS. The single-point and transect high-flow samples exhibited a much lower ratio of total DDx concentration to TSS. The low-flow and stormwater-influenced samples had low suspended solids loads (25 J mg/L or lower) compared to high-flow samples (up to 62 mg/L).

Particulate total DDx concentrations and POC concentrations are compared in Figures 5.3-73 and 5.3-74. The high-flow transect and single-point samples tended to exhibit higher total particulate DDx concentrations and lower POC concentrations in the water column. As discussed in Section 5.3.4 and shown on Figure 5.3-19, high-flow samples exhibited higher TSS concentrations and lower f_{oc} on TSS percentages. Therefore, the higher concentrations in the surface water during high-flow events (Figures 5.3-67 and 5.3-68) were present in spite of lower POC in the water column. Again, this may suggest a different source or sources of particles, possibly upstream of the Study Area, given the high inflow concentrations at RM 16 and 11 during high-flow events. Higher POC concentrations were found in transect and single-point stormwater-influenced and low-flow samples with lower total particulate DDx concentrations.

5.4.20.0 DDx Patterns and Trends

Stacked bar graphs depicting the DDx patterns for the surface water dissolved (XAD column) and particulate (XAD filter) samplings by flow condition and river mile are presented in Figures 5.3-75 and 5.3-76. The discussion of patterns and trends in the DDx distributions is qualitative based on visual examinations of the stacked bar graphs.

The DDx distributions for the dissolved fractions varied little from transect to transect within each sampling event, including the stations upstream and downstream of the Study Area. Patterns differed between flow conditions, however. The high-flow transect samples were dominated by the 4,4' isomers of DDE and DDT, with generally decreasing contributions from DDT as the transects move downriver. The low-flow and stormwater-influenced transect samples had much higher proportions of DDD, primarily the 4,4' isomer, with a substantial contribution by 2,4' DDD. For the transects, the contribution of 4,4' DDD varied with sampling event, whereas the contribution of 2,4' DDD increased overall moving downriver.

Patterns for particulate DDx were similar to dissolved DDx for high-flow transects, dominated by the 4,4' isomers of DDE and DDT. The proportion of 4,4' DDT was more consistent upstream to downstream in the particulate fraction than in the dissolved fraction. 2,4'- and 4,4' DDD dominated the particulate DDx under low-flow conditions at most transects, with generally decreasing contributions from 4,4' DDT and increasing contributions from 2,4' DDD as the transects move downriver. The March and July 2005 transect samples at stations W023 (RM 11) and W005 (RM 4) had higher fractions of 4,4' DDE than other transect samples, while the 4,4' DDE contribution in the dissolved fractions of these samples was similar to other transects. The particulate DDx patterns for the transect samples taken during stormwater-influenced flow conditions were also generally dominated by the DDD isomers, although 4,4' DDE and 4,4' DDT were also prevalent in these samples. The DDD isomers were not detected in stormwater-influenced samples from the upriver transects (W023 and W024), or from the downriver transect at RM 2 (W025) east bank sample. The total DDx concentrations at RM 16 and RM 2 transects were low during the stormwater-influenced event relative to other transects.

~~The NS and NB samples were generally similar in most flow conditions for both dissolved and particulate DDx in both transect and single-point samples. Patterns for the NB and NS samples were different at Station W011 (RM 6.3; November 2006 stormwater-influenced sampling event), Station W031 (RM 6.1; January 2007 high-flow sampling event), and for Station W024 (RM 16; November 2006 stormwater-influenced sampling event), where the patterns may be obscured by method sensitivity limits.~~

~~The DDx compound distribution for the dissolved and particulate fractions of the single-point stations were generally similar to those of the transects in high-flow conditions, with the exception of particulate DDx in the NB sample and dissolved DDx in both samples for location W031 (RM 6.1). The particulate W031 NB sample shows higher fractions of the DDD isomers and less 4,4'-DDT than the paired NS sample and the other single-point or transect stations.~~

~~During low-flow conditions, stations W016 (RM 7.2) and W015 (RM 6.9) total DDx concentrations were much higher than the other samples (5 to 60 times higher in the dissolved fraction and 14 to 80 times higher in the particulate fraction). These stations are both on the west bank of the river, located a short distance apart (0.3 mile). The particulate DDx patterns varied fairly widely between the two stations and between sampling events at each location, and were distinct from patterns in surrounding areas and at the transect locations at RM 6.3 and 11. Dissolved DDx patterns at these two locations were more consistent and included a larger fraction of DDD than is typical in the Study Area. Under stormwater-influenced conditions, the DDx concentration at nearby Station W033 (RM 7) was higher than surrounding areas, but the DDx composition did not vary as distinctly.~~

5.4.7 Total PAHs in Surface Water~~Water~~

PAH data are summarized in Tables 5.4-~~6~~5 through 5.4-11~~2~~0. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-~~8~~11, and 5.4-1~~0~~6. Single point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and 5.4-11a-d ~~through 5.4-10 (high flow events), 5.4-12 through 5.4-15 (low flow events), and 5.4-17 through 5.4-20 (storm water-influenced events)~~. All PAH surface water samples are presented in Table 5.4-16~~25~~ by sample event and sample ID number.

Dissolved and particulate PAH concentrations in surface water XAD columns and filters and PAH concentrations from the peristaltic pump samples are presented in stacked bar graphs by flow event in Figures 5.4-24~~a-c~~ and by river mile/channel position in Figures 5.4-25~~a-d~~.

PAH concentrations at the transect locations as a function of flow rate are presented in Figure 5.4-26. The values presented in this figure are averages of all measurements collected at a particular transect for each measured flow event.

Commented [EACC11]:
Discrepancies:
[This is not necessarily a complete set of discrepancies of the same nature; they are just those noticed in passing – a complete analysis for these types of discrepancies has not been performed.]
1. We don't have any data for WO24 (mile 16) in the database.
2. Map 5.3-1a lists WO38 at mile 9.9 (placing it on the E side of the river). The database we have lists it at mile 11E.
3. Map 5.3-1a plots WO38 as a green triangle, corresponding to XAD SP (according to the legend). Our database lists WO38 as Peristaltic SP.
4. The total PAH measured by XAD (C+F) and Peristaltic are highly discrepant. For the 61 cases testable in our database, 29 are discrepant by more than a factor 2 --- i.e. if both are detects (13 cases), the concentrations differ by more than a factor of 2; if one is a non-detect, the other a detect (16 cases), then the detect exceeds the DL of the non-detect by a factor more than 2. It is possible some of this discrepancy may be an artefact of the method of summing across the multiple PAH (i.e. treatment of non-detects).
5. In view of the discrepancy above, any conclusions based on trends is suspect.
6. Moreover, the apparent trends downriver seen in the XAD (C+F) and Peristaltic measurements are different in some cases, so that conclusions based on one or the other are suspect.
7. the database contains XAD – C, XAD – F, and XAD – C&F, but the last is not necessarily equal to the sum of the first two, with the discrepancy larger than can be accounted for by simple rounding of the data. This discrepancy may be explicable by the methodology used to sum across PAH (e.g. treatment of non-detects). For this section the XAD – C&F total has been replaced by the sum of XAD – C and XAD – F.

Figures 5.4-276a-b presents a scatter plot of all PAH surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow).

PAH concentrations at the transect locations as a function of flow rate are presented in Figure 5.4-27. The values presented in this figure are averages of all measurements collected at a particular transect for each measured flow event.

5.4.7.1 Total PAH Data

PAHs were analyzed by HRGC/LRMS in 151 of the 162 peristaltic sample events;[11] 61 SP-NB, 12 SP-NS, 9 SB-VI, 19 T-NB, 19 T-NS, and 31 T-VI samples. High-volume surface water samples (XAD samples) were analyzed by HRGC/HRMS in 68 of the total 114 XAD sample events; 14 SP-NB, 5 SP-NS, 9 T-NB, 9 T-NS, and 31 T-VI samples.

PAH were detected in just over half of the peristaltic samples (88 of 151 samples) with detection limits for the non-detects ranging from 0.0065 to 0.043 µg/L. PAH were detected in all the XAD samples (column sample or filter sample or both). The detection limits in non-detect peristaltic samples were well below the MCL for benzo(a)pyrene (0.2 µg/L), but intersect the range of RSLs for carcinogenic PAH (0.0000865 µg/L for 7,12-dimethylbenz(a)anthracene to 0.14 µg/L for naphthalene). There are no National or Oregon-specific water quality criteria for freshwater aquatic life for any PAH. The highest detected PAH value of 7.4 µg/L (station W031 at RM 6.1) is well below the Oregon-specific water quality guidance for the only two PAH for which there is any such guidance (acenaphthene: 520 µg/L, and naphthalene: 620 µg/L).

Detected PAH concentrations are subsequently listed as measured in the peristaltic samples or calculated as the sum of the dissolved (XAD column) and particulate (XAD filter) concentrations.

High-volume (XAD) samples were analyzed for PAHs by HRGC/HRMS (reported in pg/L). Peristaltic samples were also collected and analyzed for PAHs (reported in µg/L) by HRGC/low-resolution mass spectrometry (LRMS). Concentrations of total PAHs in surface water XAD column and filter samples are depicted as histograms with data arranged by river mile and sampling conditions (high-flow, low-flow, and stormwater-influenced) in Figures 5.3-77 and 5.3-78. Peristaltic data are presented in Figures 5.3-79 and 5.3-80. Figures 5.3-81 through 5.3-84 present the same data as histograms sorted by channel position (west and east channel and transect locations). Each of the XAD histograms presents the particulate (0.5-µm filter for XAD) and dissolved (XAD column) fractions of the total concentration as stacked bar graphs. The peristaltic data histograms present the total (filtered plus unfiltered) fraction.

Commented [EACC12]: This discussion evaluates Peristaltic and XAD (C+F) measurements together as though equally valid.

Commented [EACC13]: Here, for both counts, "sample" may include replicates –a sample event may involve taking sample + replicate, and replicates have been averaged for the sample count. The sample event count is from the (old) Table 5.4-1.

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[11] Sample events could involve replicate samples, and for XAD sampling the column and filter samples together are counted as one sample. These counts are strictly of sample events, and the values listed here are with replicates averaged together.

~~Total PAHs were detected in all surface water samples (XAD filters and columns) collected during Round 2A and 3A sampling events. In contrast, total PAHs were detected in only 58 percent of peristaltic samples.~~

~~Total PAHs measured in single-point XAD samples collected during low-flow conditions ranged from 12,500 J pg/L to 231,000 J pg/L at Station W015 (RM 6.9 in July 2005). Concentrations in transect samples measured during low-flow ranged from 3,970 J pg/L to 66,000 J pg/L at Station W005 (RM 4) in September 2006.~~

~~Total PAHs measured in single-point XAD samples collected during high-flow conditions ranged from 10,400 J pg/L to 107,000 J pg/L at Station W035 (RM 8.5) in January 2007. Concentrations measured in transect samples during high-flow ranged from 5,680 J pg/L to 59,400 J pg/L at Station W005 (RM 4 in January 2006).~~

~~Total PAHs measured in single-point XAD samples collected during the November 2006 stormwater-influenced event ranged from 5,860 J pg/L to 50,700 J pg/L at Station W033 (RM 7). Concentrations measured in transect samples during this event ranged from 2,790 J pg/L to 38,900 J pg/L at Station W005 (RM 4).~~

~~Concentrations of total PAHs measured in single-point peristaltic samples during low-flow conditions ranged from 0.00260 J µg/L to 2.46 J µg/L at Station W012 (RM 6.3 in July 2005).~~

~~Total PAHs measured in single-point peristaltic samples during high-flow conditions ranged from 0.0047 J µg/L to 7.4 µg/L at Station W031 (RM 6.1) in January 2007.~~

~~Concentrations of total PAHs measured in peristaltic single-point samples in November 2006 ranged from 0.005 J µg/L to 0.12 J µg/L at Station W033 (RM 7).~~

~~The following subsections describe observations of PAHs in the complete data set, as well as identified trends.~~

~~5.4.26.10 PAH Spatial Distribution~~

~~The distribution of total PAH concentrations (dissolved plus particulate concentrations) by river mile throughout the Study Area (and upstream to RM 16 and downstream to Multnomah Channel) is presented in Figures 5.3-85 and 5.3-86.~~

~~Three of the five highest total PAH concentrations (including the highest measured value) were measured in single-point samples at RM 6.9 (Station W015) near the west end of Railroad Bridge during low-flow conditions. The second and third highest concentrations were measured in samples collected at RM 8.5 (Station W035 during the January 2007 high-flow event; Swan Island) and RM 7.2 (Station W016 during the July 2005 low-flow event), respectively. The range of total PAH concentrations within the complete data set across the Study Area was fairly consistent between RM 11 and 2, excluding the five highest single-point values. However, total PAH concentrations~~

~~increased from RM 11 and 16 downstream to RM 4 in six of seven transect sampling events (Figure 5.3-87), suggesting some influence on surface water PAH concentrations from sources within the Study Area. The sole exception to this pattern occurred in the March 2005 low-flow event. Further downstream, at RM 2.9 (Multnomah Channel) and RM 2, concentrations decreased from those at RM 4 in high-flow, low-flow, and stormwater-influenced conditions.~~

~~5.4.26.13~~5.4.7.2 PAH Relationships to River Flow Conditions~~Rate~~~~Rate~~

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This discussion is based on the Figures cited, which are or appear to be based on XAD (C+F) data only. Some of the trends are contradicted by the Peristaltic data.

Detected PAH concentrations in samples collected during low flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.0021 J µg/L to 2.5 J µg/L (station W012 at RM 6.3W)
- SP-NS: Not sampled
- SP-VI: 0.042 J µg/L to 0.069 J µg/L (station W020 at RM 9.1 (Swan Island Lagoon))
- T-NB: 0.023 J µg/L to 0.1 J µg/L (station W027 at RM Multnomah Channel)
- T-NS: 0.012 J µg/L to 0.095 J µg/L (station W027 at RM Multnomah Channel)
- T-VI: 0.002 J µg/L to 0.099 J µg/L (station W011 at RM 6.3)

PAH concentrations in samples collected during storm water-influenced flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.0066 J µg/L to 0.098 J µg/L (Station W029 at RM 4.4W)
- SP-NS: 0.0046 J µg/L to 0.1 J µg/L (Station W029 at RM 4.4W)
- SP-VI: Not sampled
- T-NB: 0.0124 J µg/L to 0.12 J µg/L (Station W033 at RM 7.0W)
- T-NS: 0.00929 J µg/L to 0.097 J µg/L (Station W033 at RM 7.0W)
- T-VI: 0.004 J µg/L to 0.098 J µg/L (Station W025 at RM 2W)

PAH concentrations in samples collected during high flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.0053 J µg/L to 0.081 J µg/L (Station W036 at RM 8.6W)

- SP-NS: 0.0037 J µg/L to 0.31 J µg/L (Station W036 at RM 8.6W)
- SP-VI: Not sampled
- T-NB: 0.0046 J µg/L to 7.4 µg/L (Station W031 at RM 6.1W)
- T-NS: 0.0045 J µg/L to 0.16 J µg/L (Station W035 at RM 8.5 (Swan Island Lagoon))
- T-VI: 0.00087 J µg/L to 0.082 J µg/L (Station W023 at RM 11M)

PAH concentrations were generally higher in low flow samples as compared to the high flow and storm water-influenced flow samples, suggesting that inflow concentrations at high flow rates overwhelm local effects and PAH concentrations (Figure 5.4-24~~a-c~~). The transect samples (Figure 5.4-26~~7~~) suggest that there is a source of PAHs in the Downtown Reach (between RM 11 and RM 16), since all but the storm water events show the concentrations at the RM 11 transect greater than RM 16 transect. During three of the four low flow sampling events (November 2004, July 2005, and September 2006), one high flow event (January 2006) and the storm water event (November 2006), there is some indication that sources of PAH are located between RM 11 and RM 6. However, the March 2005 low flow event did not show this same trend. Two of the low flow events (July 2005 and September 2006) indicate that there is also a source between RM 6 and RM 4, and this is also indicated by a high flow event (February 2007) and the storm water event (November 2006).

~~Total PAH concentrations as a function of flow rate are presented in Figures 5.3-88 and 5.3-89. As previously noted, four of the five highest concentrations of total PAHs were measured in single-point samples collected during low-flow conditions. Total PAH concentrations tended to vary within a flow condition rather than over the range of flow conditions sampled, although elevated PAHs were evident in low-flow samples from RM 7 to 2 compared to the high-flow and stormwater-influenced sampling events. Downstream near RM 2, the low-flow sample concentration ranges decreased relative to ranges observed further upstream within the Study Area (Figure 5.3-77).~~

5.4.7.3 ~~PAH~~ Spatial Distribution of PAHs

Six of the sample concentrations for PAH exceeded the MCL for benzo(a)pyrene (0.2 µg/L). These were recorded at the following stations:

- WO31 (RM 6.1W) 7.4 µg/L (February 2007, high flow)
- WO12 (RM 6.3W) 2.5 µg/L (July 2005, low flow)
- WO12 (RM 6.3W) 1.3 µg/L (November 2004, low flow)
- WO21 (RM 8.7 in Swan Island Lagoon) 0.31 µg/L (July 2005, low flow)

Commented [EACC15]: Figure 5.3-87 (now 5.4-27) does not specify what data were used to construct it. It appears to be based on XAD (C+F) data only, and should require T-VI data. But Figure 5.3-87 shows data points at miles 3 and 4 although there are no T-VI data at miles 3 and 4 in our database.

Commented [EACC16]: We do not have data for RM16. This is WO24, which has apparently been filtered out of the dataset we are using.

Commented [EACC17]: This section is based on the combined Peristaltic and XAD (C+F) data.

Commented [EACC18]: 40CFR141 lists only benzo(a)pyrene as having an MCL, but the appearance of a bracketed (PAH or PAHs) in the Appendices to subparts O and Q suggest that there may be reporting requirements if total PAH exceed the MCL for benzo(a)pyrene.

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- WO36 (RM 8.6W) 0.31 µg/L (February 2007, high flow)
- WO15 (RM 6.9W) 0.234 µg/L (July 2005, low flow)

All but the last of these were measured in Persistaltic samples. The first three appear to be distinct outliers on the distribution of Peristaltic samples. All detected samples, and all the detection limits for non-detect samples, exceed the lowest RSL for any PAH (0.000086 µg/L for ~~7,~~1,2-dimethylbenze(a)anthracene); and 127 (of 219) samples exceed the RSL (0.029 µg/L) for the prototypical PAH benzo(a)pyrene, with a further two non-detects exceeding this value. Compared with the ODEQ criterion for human health for the carcinogenic PAH (0.0013 µg/L) or the NRWQC for human health for carcinogenic PAH (0.0038 µg/L),[12] all 156 detected samples exceeded and 63 were non-detects with detection limits exceeding; no sample was measured at a lower concentration.

Commented [EACC19]: A formal test would be difficult, because of the many non-detects.

All measured concentrations are below the two PAH NRWQC for freshwater aquatic life (acenaphthene: 520 µg/L, and naphthalene: 620 µg/L). ODEQ has no criteria for PAH for freshwater aquatic life.

~~5.4.8.0 Distribution between PAH Dissolved and Particulate Fractions~~

~~The following subsections describe the observed trending of the dissolved and total fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS. Section 5.3.9.4 provides a discussion of PAH patterns and trends (i.e., LPAHs, HPAHs), which may assist with the identification of observed concentrations in the Study Area.~~

~~5.4.10.0.0 PAH Particulate and Dissolved Concentrations~~

~~The spatial distribution of dissolved and particulate total PAH concentrations is presented on histograms for each surface water sample by flow event type and river mile on Figure 5.3-77; Figure 5.3-78 presents the same data with a reduced y-axis scale to better show lower concentrations. Figures 5.3-81 through 5.3-84 present the same data arranged by channel position. The majority of total PAH concentrations were found in the dissolved rather than the particulate phase. However, there was one notable exception to this trend: Station W035 at RM 8.5 collected during the January 2007 high-flow event. Both the NB and NS samples collected in January 2007 exhibited a much greater particulate to dissolved ratio. Also, at Stations W011 (RM 6.3) and W005 (RM 4) the NB samples had noticeably higher particulate total PAH concentrations in the low-flow and stormwater-influenced sampling events. In the January 2007 high-flow sampling event, this pattern was reversed at Station W035 (RM 8.5), and the NS sample had the highest particulate total PAH concentration.~~

~~The dominance of the dissolved fraction is also illustrated in scatter plots of particulate and dissolved data on Figures 5.3-90 and 5.3-91. Linear regression lines are shown for the high-flow, low-flow, and stormwater-influenced sets of transect and point data. The~~

[12] Neither the ODEQ criteria or the NRWQC address naphthalene.

apparently unique ratio at RM 8.5 is well illustrated on these figures (data points in the lower right quadrant) and does not appear to apply to other high-flow samples. The unique ratio may suggest a different character/source of PAHs and/or suspended solids concentration and character for this sample location.

5.4.13.0.0 PAH Associations with Suspended Solids

Total PAH concentrations as a function of TSS are presented in Figures 5.3-92 and 5.3-93. High-flow samples (single-point and transect) exhibited the widest range and highest concentrations of TSS but generally lower total PAH concentrations compared to the majority of the data set. However, there does appear to be a trend of gradually increasing total PAH concentrations with higher TSS values (somewhat linear) for the high-flow samples. Otherwise, the low-flow and stormwater-influenced samples tended to cluster together exhibiting low TSS but varying PAH concentrations. The stormwater-influenced (single-point and transect) and low-flow single-point samples tended to exhibit this pattern most prevalently, with TSS values below 12 mg/L.

Samples collected from RM 8.5 during high-flow in January 2007 did not adhere to the pattern of other samples collected during this particular flow regime as they exhibited high concentrations of total PAHs relative to TSS (Figures 5.3-92 and 5.3-93). Although total PAHs measured in these samples were high relative to TSS, the particulate concentrations were much greater than the dissolved fractions (Figures 5.3-77, 5.3-78, 5.3-90, and 5.3-91).

Particulate total PAH concentrations and POC concentrations are compared in Figure 5.3-94. The high-flow samples (single-point and transect) exhibited relatively low total PAH concentrations and POC. The low POC values are consistent with the lower observed f_{oc} of the suspended solids during this flow condition (Figure 5.3-19). Several high-flow samples (e.g., the sample with the highest particulate total PAH concentration at Station W035, NS) exhibited POC values equal to zero (Figure 5.3-94). The explanation for this is that the calculated POC was set to equal zero if the DOC was greater than the TOC. This scenario provides further confirmation that the high-flow events are characterized by suspended solids with low f_{oc}.

5.4.17.0 PAH Patterns and Trends

Stacked bar graphs depicting the PAH distribution by individual PAHs and summed by number of rings in the surface water dissolved (XAD column) and particulate (XAD filter) samples by flow condition and river mile are presented in Figures 5.3-95 and 5.3-96. A summary of PAHs included in each sum is provided in Section 5.1.8.4.

The dissolved PAH profiles varied between locations and flow events. During all sampling events, LPAHs (i.e., two-ring and three-ring PAHs) accounted for at least 50 percent of the dissolved PAHs at most transect, as well as single-point, stations. The two-ring PAHs (i.e., naphthalene and 2-methylnaphthalene) were dominant in many samples. In several samples, these results were restated as undetected during data validation, as discussed below, confounding the interpretation. The principal three-ring

PAHs in many of the samples were acenaphthene and phenanthrene, although fluorene and anthracene were also present in many of the samples. Fluorene is dominant in two stormwater-influenced samples, collected from W023 (RM 11) and W024 (RM 16).

Generally, the remainder of the dissolved PAH profile consisted of four-ring HPAHs, primarily fluoranthene and pyrene in the high- and low-flow events. With several exceptions, the four-ring PAHs in the November 2006 stormwater-influenced sampling event were chiefly chrysene upstream of RM 8.5 and fluoranthene downstream of this point.

PAH patterns are affected by the presence of elevated detection limits, which result when individual PAHs are restated as undetected in the samples, since non-detects are treated as zeros in the evaluation of PAH patterns. Elevated detection limits may obscure the presence of a PAH at a concentration above the MDL. The concentrations reported by the laboratory for each of the PAHs in one or more samples were restated as undetected during data validation. Reasons for restating data as undetected included PAHs detected in laboratory and field blanks and details related to identification of the PAHs (i.e., ion abundance criteria were not met on the mass spectrometer). Data for XAD filter and column samples were affected. Results for LPAHs were restated as undetected more frequently than HPAHs. The evaluation of PAHs in this section takes elevated detection limits into consideration.

The PAH profiles in the particulate fractions also varied between sampling locations and flow events. Among transect locations, the low-flow and stormwater-influenced samples included primarily HPAHs with four and five rings, with fluoranthene, pyrene, and the benzofluoranthene isomers prevalent but many other HPAHs present as well. Samples from the high-flow sampling events were still predominantly four- and five-ring HPAHs but had more contribution of LPAHs, primarily the three-ring phenanthrene. The six-ring PAHs in the high- and low-flow events consisted of both benzo(g,h,i)perylene and indeno(1,2,3-cd)pyrene, while the stormwater event consisted almost entirely of benzo(g,h,i)perylene. Particulate PAHs in single-point samples varied from these patterns in many locations, particularly during low-flow conditions.

There was generally little difference in composition between the NS and NB samples for both transect and single-point samples. In the November 2006 stormwater-influenced sampling event, the dissolved NS samples at stations W024 (RM 16), W035 (RM 8.5), and W005 (RM 4) all had high contributions from 2-methylnaphthalene (a two-ring PAH) that was not present in the NB samples. The NS samples also had total dissolved PAH concentrations more than double the NB samples. A similar pattern is not seen in the particulate fractions of these samples. The higher NS concentrations may be related to a hydrocarbon sheen observed during sample collection for the stormwater event that was not thoroughly mixed within the water column, resulting in higher concentrations in the NS samples than the NB samples.

5.4.8 BEHP in Surface Water

BEHP data are summarized in Tables 5.4-~~6~~5 through 5.4-11~~2~~0. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-~~8~~11, and 5.4-1~~0~~6. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d,~~.~~ and ~~through~~ 5.4-11a-d~~0 (high flow events), Tables 5.4-12 through 5-4.14 (low flow events), and 5.4-17 through 5.4-20 (storm water-influenced events)~~. All BEHP surface water sample results are presented in Table 5.4-17~~26~~ by sample event and sample ID number.

Dissolved and particulate BEHP concentrations in surface water XAD columns and filters and BEHP concentrations from the peristaltic pumps are presented in stacked bar graphs by flow event and by river mile/channel position on Figures 5.4-28~~a-c~~ and 5.4-29~~a-b~~, respectively.

BEHP concentrations at the transect locations as a function of flow rate are presented on Figure 5.4-30. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

Figure 5.4-3~~1~~0 presents a scatter plot of all BEHP surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow.

~~BEHP concentrations at the transect locations as a function of flow rate are presented on Figure 5.4-31. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.~~

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5.4.8.1 BEHP Data

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BEHP was analyzed by EPA methods 8270C or 525.2 in all of the total 163 peristaltic samples collected; 66 SP-NB samples, 12 SP-NS samples, nine SP-VI samples, 22 T-NB samples, 22 T-NS samples, and 32 T-VI samples. BEHP was analyzed in high-volume surface water samples (XAD samples) by AXYS Method MLA-027 Rev 01 in 24 of the total 123 XAD samples collected; 15 SP-NB samples and nine T-VI samples.

Commented [RRL20]: Based on samples on the BEHP page of the accompanying spreadsheet file. Spreadsheet may be missing the NS sample from W038. Check the indicated river mile for W038 in the spreadsheet (11 in the spreadsheet, 9.9 on the accompanying figures). Check treatment of duplicates. Should W024 (River Mile 16) be included in the database?

Commented [RRL21]: What type of analysis is this?

BEHP was not detected in the majority of the peristaltic samples (148 of 163 samples) with detection limits ranging from 0.098 to 4.1 µg/L, which are less than the MCL (6 µg/L). All but one of the detection limits are also less than the selected TRV from the BERA (the Tier II Secondary Chronic Value; 3.0 µg/L).

Detections of BEHP were limited to 15 samples collected during the Round 3A sampling event at the following stations:

- W005 (T-NS and T-NB; RM 3.9),
- W011 (T-NB; RM 6.3),
- W023 (T-VI; RM 11M),

- W024 (T-NB; RM 16),
- W025 (T-VI; RM 2E and 2W),
- W027 (T-NB; Multnomah Channel),
- W029 (SP-NB; RM 4.4W),
- W032 (SP-NB; RM 6.9E),
- W033 (T-NS; RM 7.0W), and
- W036 (SP-NS; RM 8.6W).

Detected BEHP concentrations in peristaltic samples ranged from 0.7 µg/L to 6.8 J µg/L. During low flow conditions, BEHP was detected in four samples at concentrations ranging from 0.7 µg/L to 1.5 µg/L (T-VI sample; station W025 at RM 2E). During storm water-influenced flow conditions, BEHP was detected in one T-NB sample at a concentration of 6.8 J µg/L (station W005 at RM 3.9). During high flow conditions, BEHP was detected in 10 samples at concentrations ranging from 0.98 J µg/L to 3.5 J µg/L (SP-NB sample; station W032 at RM 6.9E).

BEHP concentrations, calculated as the sum of the dissolved (XAD column) and particulate (XAD filter) concentrations, were detected in nine of 24 samples, all collected during low flow conditions. BEHP concentrations in these samples ranged as follows:

- SP-NB: 0.0078 J µg/L to 0.033 µg/L (station W015 at RM 6.9W);
- T-VI: 0.0091 J µg/L to 0.023 J µg/L (station W023E at RM 11); and
- SP-NS, SP-VI, T-NS, T-NB: No detects.

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5.4.8.2 BEHP Relationship to River Flow ~~Rate~~Conditions

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Detected BEHP concentrations and frequencies were relatively consistent regardless of flow rate. The frequency of detection was 5% for low flow event peristaltic sampling results; 24% for high flow event peristaltic sampling results; 3% for storm water flow peristaltic sampling events, and 38% for low flow event XAD sampling results.

Detected BEHP concentrations in low flow peristaltic samples ranged from 0.7 to 1.5 µg/L (station W025 at RM 2E) in September 2006. Detected BEHP concentrations in high flow peristaltic samples ranged from 0.98 J to 3.5 J µg/L (station W032 at RM 6.9E) in February 2007. BEHP was detected in only one of 37 storm water-influenced flow samples at a concentration of 6.8 J µg/L (station W005 at RM 3.9) in November 2006.

Detected BEHP concentrations in low flow XAD samples ranged from 0.0078 J µg/L to 0.033 µg/L (station W015 at RM 6.9W).

5.4.8.3 ~~BEHP~~ Spatial Distribution of BEHP

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One sample result exceeds the MCL for BEHP (6 µg/L). Detected concentrations from two sample stations exceeded the TRV from the BERA (3.0 µg/L): W005 (RM 3.9) and W032 (RM 6.9E).

The highest concentrations (>3 µg/L) were collected at the following stations:

- W005 (RM 3.9),
- W032 (RM 6.9E).

The next highest concentrations (>1.5 µg/L but <3 µg/L) were collected at the following stations during high flow conditions:

- W036 (RM 8.6W),
- W011 (RM 6.3),
- W024 (RM 16),
- W029 (RM 4.4W), and
- W025 (RM 2E).

5.4.9 Total Chlordanes in Surface Water

Total chlordanes data are summarized in Tables 5.4-6~~5~~ through 5.4-11~~20~~. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-8~~11~~, and 5.4-10~~6~~. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and ~~through~~ 5.4-11a-d~~0 (high flow events), 5.4-12 through 5.4-15 (low flow events), and Tables 5.4-17 through 5.4-20 (storm water-influenced events)~~. All chlordanes surface water sample results are presented in Table 5.4-18~~27~~ by sample event and sample ID number.

Total chlordanes concentrations in surface water XAD columns and filters as well as concentrations from the peristaltic pumps are presented in stacked bar graphs by flow low flow, storm water-influenced, or high flow events and by river mile/channel position on Figures 5.4-32~~a-c~~ and 5.4-33~~a-c~~, respectively.

Total chlordane concentrations at the transect locations as a function of flow rate is presented on Figure 5.4-34. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

Figure 5.4-354 presents a scatter plot of total chlordane surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow).

~~Total chlordane concentrations at the transect locations as a function of flow rate is presented on Figure 5.4-35. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.~~

5.4.9.1 Total Chlordanes Data

Total chlordanes were analyzed by EPA Method 8081A for all of the 78 peristaltic samples collected. High-volume surface water samples (XAD samples) were analyzed for total chlordanes by the AXYS method for pesticides for each of the 76 XAD samples collected.

Chlordanes were not detected in the majority of the peristaltic samples (74 of 78 nondetect samples) with total chlordane concentrations ranging from 0.0010 µg/L to 0.0029 µg/L and detection limits for undetected results ranging from 0.0024 to 0.00047 µg/L. Total chlordanes were identified in each of the 76 XAD samples, with detected concentrations ranging from 0.000014 µg/L to 0.00024 µg/L. All of these detected and undetected results are below the acute (2.4 µg/L) and chronic (0.0043 µg/L) Oregon water quality criteria for aquatic life as well as the MCL (2 µg/L). All of the peristaltic detected and undetected results are greater than the Oregon water quality criterion for human health (0.000081 µg/L) that is protective of drinking water plus the consumption of organisms. The majority of 76 XAD samples are less than this criterion; only five sample results exceed the criterion, with concentrations ranging from 0.000083 µg/L to 0.00024 µg/L. These results suggest that the XAD samples analyzed using the AXYS method for pesticides achieved sufficiently low detection limits to determine that total chlordanes are below applicable human health and ecological criteria in the majority of samples and there does not appear to be total chlordanes source areas of contamination.

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5.4.9.2 Total Chlordanes Relationship to River Flow ~~Rate~~Conditions

Detected total chlordanes concentrations were relatively consistent, with concentrations slightly higher during high flow conditions. Of the four peristaltic sample results that exceed the lowest AWQC human health criterion (0.000081 µg/L), one was from the low flow event conducted during July 2005 and three were from the high flow event conducted in March 2007. Of the five XAD sample results that exceed the criterion, one is from a low flow event conducted in November 2004 and four are from the high flow events conducted in February and March 2007. All storm water-influenced results are less than applicable human health and ecological criteria.

There were no peristaltic transect samples collected during low flow events. There was one detection out of 50 samples for single-point peristaltic samples collected during low flow events. XAD single-point sample concentrations ranged from 0.000017 to a maximum of 0.00024 µg/L during July 2005 and transect sample concentrations ranged from 0.000014 to 0.000063 µg/L.

There were no peristaltic transect samples collected during high flow events. Single-point peristaltic sample concentrations ranged from 0.0010 µg/L to a maximum of 0.0015 µg/L during the high flow event conducted in March 2007. XAD single-point sample concentrations ranged from 0.000047 µg/L to a maximum concentration of 0.000083 µg/L and transect sample concentrations ranged from 0.000033 µg/L to a maximum of 0.000095 µg/L during the high flow event conducted in March 2007.

All peristaltic single-point and transect sample results were undetected during the storm water-influenced event conducted in November 2006. XAD single-point sample concentrations ranged from 0.000021 to 0.000049 µg/L. XAD transect sample concentrations ranged from 0.000024 to 0.000045 µg/L.

5.4.9.3 ~~Total Chlordanes~~ Spatial Distribution of Total Chlordanes

None of the sample results exceed the 2 µg/L drinking water MCL for total chlordanes, or the ODEQ ecological acute (2.4 µg/L) or chronic (0.0043 µg/L) criteria for the protection of aquatic life. Each of the four detected concentrations from peristaltic samples exceed the AWQC for human health (0.000081 µg/L). Detection limits were higher for the peristalitic samples than the XAD samples. The samples with concentrations greater than the human health criterion were collected at the following stations:

- W002 (RM 2.2W),
- W029 4.4W, and
- W030 5.5E, NS and NB.

The sample from station W002 was collected during the low flow event conducted in July 2005 and the samples from stations W029 and W030 were collected during the high flow event conducted in March 2007.

Lower detection limits were achieved for the XAD samples. Total chlordanes were detected in each of the 76 XAD samples with concentrations in five samples slightly exceeding the AWQC for human health (0.000081 µg/L). The samples were collected at the following stations:

- W005 (RM 3.9) (two samples),
- W015 (RM 6.9W),
- W023E (RM 11E) and
- W031 (RM 6.1W),

5.4.24 The sample from station W015 was collected during low flow conditions in November 2004; the samples from stations W015 and W023 were collected during high flow conditions in March 2007. The sample from station W031 was collected during high flow conditions in February 2007. The low detection limits for the XAD samples and the low frequency of exceedance of the human health AWQC criterion suggest that specific source areas do not exist for total chlordanes. ~~**Additional Indicator Chemicals in Surface Water**~~

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~~This section discusses the occurrence and distribution of seven additional ICs in surface water within the Study Area. These additional ICs are included because they figure prominently in the CSM for the Site. The narrative in this section is abbreviated compared to the evaluation of ICs above and includes references to figures and tables to provide a complete picture of the distribution.~~

~~5.4.24.1 TCDD TEQ~~

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~~High-volume surface water sampling results for PCDD/Fs (analyzed by HRGC/HRMS) were used to calculate TCDD TEQ values. TCDD TEQs were calculated using the 2005 WHO consensus TEF values for mammals (Van den Berg et al. 2006) as the sum of each detected congener concentration multiplied by the corresponding TEF value. Concentrations of TCDD TEQ in surface water XAD column and filter samples are depicted in Figure 5.3-97.~~

~~TCDD TEQ measured in single-point samples collected during low-flow conditions ranged from 0.110 J pg/L to 0.917 J pg/L at Station W013 (RM 6.7) in July 2005. Concentrations in transect samples measured during low-flow ranged from 0.0181 J pg/L to 0.327 J pg/L at Station W005 (RM 4 in July 2005).~~

~~TCDD TEQ measured in single-point samples collected during high-flow conditions ranged from 0.0491 J pg/L to 0.168 J pg/L at Station W035 (NS; RM 8.5) in January 2007. Concentrations measured in transect samples during high-flow ranged from 0.0113 J pg/L to 0.0912 J pg/L at Station W023 (RM 11 in January 2006).~~

~~TCDD TEQ measured in single-point samples collected during the November 2006 stormwater-influenced event ranged from 0.0777 J pg/L to 0.212 J pg/L at Station W033 (NB; RM 7). Concentrations measured in transect samples during this event ranged from 0.0133 J pg/L to 0.278 J pg/L at RM 11, Station W023E.~~

~~The TCDD TEQ particulate concentrations were greater than the dissolved values, consistent with the total PCDD/F data. TCDD TEQ concentrations were lowest upstream of the Study Area at RM 16 and at RM 2, the downstream extent (Figures 5.3-97 and 5.3-98).~~

~~5.4.25.0 Total Chlordanes in Surface Water~~

~~High-volume (XAD) samples were analyzed for total chlordanes (reported in pg/L) by HRGC/HRMS. Peristaltic samples were also collected and analyzed for total~~

~~chlordanes (reported in µg/L) by routine methodology (i.e., EPA 8081A). Dissolved and particulate total chlordanes concentrations in surface water XAD column and filter samples are depicted in histograms by flow event type in Figures 5.3-99 and 5.3-100. Peristaltic data are presented in Figure 5.3-101. The same data are plotted by channel position in Figures 5.3-102 through 5.3-104. Total chlordanes were detected in 85 percent of particulate samples (XAD filters), 100 percent of dissolved samples (XAD columns), and 34 percent of peristaltic samples.~~

~~Total chlordanes measured in single-point XAD samples collected during low-flow conditions ranged from 17.3 J pg/L to 241 J pg/L at Station W015 (RM 6.9) in November 2004. Concentrations in transect samples measured during low-flow ranged from 13.4 J pg/L to 58.8 J pg/L (Station W005 [NB] at RM 4 in September 2006).~~

~~Total chlordanes measured in single-point XAD samples collected during high-flow conditions ranged from 46.6 J pg/L to 85.9 J pg/L (Station W033 [NB] at RM 7) in January 2007. Concentrations measured in transect samples during high-flow ranged from 33.6 J pg/L to 94.3 J pg/L (Station W005 [NB] at RM 4) in January 2007.~~

~~Total chlordanes measured in single-point XAD samples collected during the November 2006 stormwater-influenced event ranged from 7.3 J pg/L to 36.8 J pg/L at Station W033 (NS; RM 7). Concentrations measured in transect samples during this event ranged from 13.4 J pg/L to 37.6 J pg/L at Station W027 (NS; RM 2.9).~~

~~Total chlordanes were detected in only one single-point peristaltic sample during low-flow conditions: 0.0021 J µg/L at Station W002 (RM 2.2) in July 2005.~~

~~Total chlordanes were detected in three single-point peristaltic samples during high-flow conditions: 0.00029 J µg/L at Station W029 (NB; RM 4.4), 0.00051 µg/L at W030 (NS; RM 5.5), and 0.0006 NJ µg/L at W030 (NB; RM 5.5) in January 2007.~~

~~Total chlordanes were detected in two single-point peristaltic samples during the stormwater-influenced event: 0.00055 NJ µg/L at Station W038 (NS; RM 9.9) and 0.0016 J µg/L at Station W036 (NS; RM 8.6).~~

5.4.10 ~~The total chlordanes dissolved concentrations were greater than the particulate values, with a major exception at RM 6.9 (W015). Total chlordanes concentrations at RM 16 and at RM 2 were similar except the high-flow event, in which upstream sample concentrations were generally higher.~~ Aldrin In Surface Water

Aldrin data are summarized in Tables 5.4-6~~5~~ through 5.4-11~~20~~. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-8~~11~~, and 5.4-10~~6~~. Single point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and ~~through~~ 5.4-11a-d~~0~~ ~~(high-flow samples), Tables 5.4-12 through 5.4-15 (low-flow events), and Tables 5.4-17 through 5.4-20 (storm-water-influenced events)~~. All aldrin surface water sample results are presented in Table 5.4-19~~28~~ by sample event and sample ID number.

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Commented [EACC22]: Discrepancies
1. The database has 4 WO13 entries, 3 listed at RM 6.7, one at 6.9E. Two of those listed at 6.7 are given as SP-NB-1 XAD and SP-NB-2 XAD, one as SP-NB-2 Peristaltic, and the one at 6.9E as Peristaltic SP-NB-1. Map 5.3-1a lists/plots WO13 at 6.9E, but as XAD SP. For this evaluation the 4 entries are treated as distinct (although they could be pairwise replicates).

Dissolved and particulate aldrin concentrations in surface water XAD columns and filters and aldrin concentrations from the peristaltic pumps are presented in stacked bar graphs by flow event type on Figures 5.4-36~~a-c~~ and by river mile/channel position on Figures 5.4-37~~a-b~~.

Aldrin concentrations at the transect locations as a function of flow rate is presented on Figures 5.4-38. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

Figure 5.4-39~~8~~ presents a scatter plot of all aldrin surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow).

~~Aldrin concentrations at the transect locations as a function of flow rate is presented on Figures 5.4-39. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.~~

5.4.10.1 Aldrin Data

Aldrin was measured by EPA method 8081A in 79 of the total 162 peristaltic sample events;[13] 54 SP-NB, 10 SP-NS, 9 SB-VI, 2 T-NB, and 4 T-NS samples. High-volume surface water samples (XAD samples) were analyzed by HRGC/HRMS in 88 of the total 123 XAD samples collected; 24 SP-NB, 9 SP-NS, 12 T-NB, 12 T-NS, and 31 T-VI samples.

Aldrin was not detected in all but one of the peristaltic samples, with detection limits ranging from 0.000057 to 0.0058 µg/L; all but 4 of these detection limits were less than 0.001 µg/L. The single detect was a SP-NB measurement of 0.0052 µg/L at WO30 (RM 5.5E) during high flow. Since this was 319 times the highest detect in the XAD data (discussed below), and the non-detect SP-NS sample at the same location and time had the (higher) detection level of 0.0058 µg/L, this detection must be considered suspect. For comparison, the ODEQ water quality criterion for human health is 0.000005 µg/L, although there are no chronic water quality criteria for aquatic life and all measurements and detection limits were far below the acute criterion for aquatic life of 3.0 µg/L (ODEQ and NRWQC).

~~**5.4.33**~~ Aldrin concentrations, calculated as the sum of the dissolved (XAD column) and particulate (XAD filter) concentrations,[14] were detected in 76 of the 88 samples, with detection limits in the non-detects ranging from 0.000000613 to 0.0000186 µg/L.

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But see Discrepancy comment 1 above.

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Here, for both counts, "sample" may include replicates –a sample event may involve taking sample + replicate, and replicates have been averaged for the sample count. The sample event count is from the (old) Table 5.4-1.

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[13] Sample events could involve replicate samples, and for XAD sampling the column and filter samples together are counted as one sample. These counts are strictly of sample events, and the values listed here are with replicates averaged together.

[14] Non-detects in either column or filter were treated as zero concentrations in this sum, but the detection limit when both column and filter were non-detect was set to the sum of the detection limits in column and filter.

5.4.10.2 Aldrin Relationship to River Flow ~~Rate~~Conditions

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Detected aldrin concentrations in samples collected during low-flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.00000031 J µg/L to 0.0000163 J µg/L (station W015 at RM 6.9W)
- SP-NS: Not sampled
- SP-VI: Not sampled
- T-NB: 0.00000439 J µg/L to 0.00000662 J µg/L (station W005 at RM 3.9)
- T-NS: 0.000001791 J µg/L to 0.0000046 J µg/L (station W027 at Multnomah Channel)
- T-VI: 0.000000296 J µg/L to 0.00000409 J µg/L (station W025 at RM 2E)

Detected aldrin concentrations in samples collected during storm water-influenced flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.00000141 J µg/L to 0.00000366 J µg/L (station W031 at RM 6.1W)
- SP-NS: 0.000000635 J µg/L to 0.00000484 J µg/L (station W033 at RM 7.0W)
- SP-VI: Not sampled
- T-NB: 0.00000201 J µg/L to 0.00000575 J µg/L (station W027 at Multnomah Channel)
- T-NS: 0.00000204 J µg/L to 0.00000263 J µg/L (station W027 at Multnomah Channel)
- T-VI: 0.0000011 J µg/L to 0.00000326 J µg/L (station W025 at RM 2W)

Detected aldrin concentrations in samples collected during high flow conditions ranged as follows (the station listed is for the maximum):

- SP-NB: 0.000000514 J µg/L to 0.00000301 J µg/L (station W030 at RM 5.5E)

- SP-NS: 0.00000245 J µg/L to 0.00000352 J µg/L (station W035 at RM 8.5 in Swan Island Lagoon)
- SP-VI: Not sampled
- T-NB: 0.00000281J µg/L to 0.00000475 J µg/L (station W027 at Multnomah Channel)
- T-NS: 0.00000257 J µg/L to 0.000004 J µg/L (station W005 at RM 3.9)
- T-VI: 0.00000124 J µg/L to 0.00000599 J µg/L (station W025 at RM 2M)

Average aldrin concentrations were slightly lower in the low flow than in the high flow XAD samples. The aldrin concentrations in the storm water-influenced samples may have been higher or lower than either — the proportion of non-detect samples and their detection limits results in ambiguity.

Concentration trends along the river were examined by using T-VI XAD samples, either single samples (November 2004, March 2005, July 2005, January 2006, January 2007, March 2007) or averages of East, West, and Middle samples (September 2006, November 2006). Low flow samples are consistent in showing a decreasing concentration trend between RM 6 and 1 in the three events with suitable samples (November 2004, March 2005, July 2005), consistent with no sources in this range. The high flow event of January 2006 and the storm water event of November 2006 indicate an increasing concentration between RM 3 and RM 1, suggesting sources within that range, although interpretation of the storm water event is ambiguous because of non-detects. One low flow event (September 2006) and one high flow event (January 2007) showed an increase in concentration between RM 11 and RM 2, suggesting sources within that range, while a second high flow event (March 2007) showed a decrease in concentration.

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Commented [EACC25]: There is currently no graph of these transect samples in" 2011-08-29_DF RI_Sec5.3_Figures.pdf". There is a graphic in the accompanying workbook that shows these trends.

5.4.10.2 ~~Aldrin~~ Spatial Distribution of Aldrin

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There is no MCL for aldrin. All (XAD and peristaltic) sample detections and detection limits for non-detects were below the RSL for tapwater (0.004 µg/L), except for the one peristaltic detect and detection limit discussed above. Five XAD samples exceeded the ODEQ criterion for human health (water + organisms) of 0.000005 µg/L:

- W011 (RM 6.3 T-NB)
- W027 (Multnomah Channel T-NB)
- W025 (RM 2M T-VI)
- W005 (RM 3.9 T-NB)

- W015 (RM 6.9W SP-NB)

and none of the XAD samples exceeded the NRWQC of 0.000049 µg/L.

The highest XAD concentration measurement of 0.0000163 µg/L was in a SP-NB measurement at W015 (RM 6.9W) but the nearest available measurements in W032 and W033 and downriver in W011 do not suggest a source area.

5.4.11 Dieldrin in Surface Water

Dieldrin data are summarized in Tables 5.4-6~~5~~ through 5.4-11~~20~~. Transcect samples are summarized by flow event in Tables 5.4-6, 5.4-8~~11~~, and 5.4-11~~6~~. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and ~~through~~ 5.4-11a-d~~0~~ ~~(high flow events), Tables 5.4-12 through 5.4.15 (low flow events), and Tables 5.4-17 through 5.4-20 (storm water-influenced events)~~. All dieldrin surface water sample results are presented in Table 5.4-20~~9~~ by sample event and sample ID number.

Dieldrin concentrations in surface water XAD columns and filters and dieldrin concentrations from the peristaltic pumps are presented in stacked bar graphs by flow event and by river mile/channel position on Figures 5.4-40~~a-c~~ and 5.4-41~~a-b~~.

Dieldrin concentrations at the transect locations as a function of flow rate is presented on Figure 5.4-42. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

Figure 5.4-43~~2~~ presents a scatter plot of all dieldrin surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow).

~~Dieldrin concentrations at the transect locations as a function of flow rate is presented on Figure 5.4-43. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.~~

5.4.11.1 Dieldrin Data

Dieldrin was analyzed by EPA method 8081 and 8081A for the 79 peristaltic samples and by AXYS method for pesticides for the 88 XAD samples. Dieldrin was detected in only 3 of 79 (3.8%) of the peristaltic samples. Dieldrin was detected in all 88 XAD samples.

The range of detected concentrations in the 3 SP-NB peristaltic samples in which dieldrin was detected was 0.0010 to 0.0012 µg/L (W036, RM 8.6, February 2007) and W028, RM 3.6E, March 2007).

Dieldrin concentrations, calculated as the sum of the XAD column and XAD filter concentrations, ranged from 0.0000167 to 0.000384 µg/L. The range of dieldrin

concentrations measured under all flow conditions, by XAD sample type, are presented below.

- SP-NB: 0.0000227 to 0.0001362 J µg/L
- SP-NS: 0.0000319 J to 0.0001298 J µg/L
- T-NB: 0.0000306 J to 0.0001577 µg/L
- T-NS: 0.00000322 J to 0.0001593 J µg/L
- T-VI: 0.00001673 J to 0.0003837 J µg/L

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5.4.11.2 Dieldrin Relationships to River Flow ~~Rate~~Conditions

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Where detected, dieldrin concentrations were relatively consistent in both low flow and high flow samples, and were also relatively similar across sample types. The range of dieldrin concentrations by XAD sample type are presented below.

Low Flow XAD (combined column + filter)

- SP-NB: 0.0000227 to 0.0000625 µg/L (W015 at RM 6.9W, November 2004)
- SP-NS: Not Sampled
- T-NB: 0.00003481 J to 0.00004866 J µg/L (W005 at RM 3.5, September 2006)
- T-NS: 0.0000353 J to 0.00004703 J µg/L (W005 at RM 3.5, September 2006)
- T-VI: 0.00001673 J to 0.00004615 J µg/L (W023 at RM 11, September 2006)

High Flow XAD (combined column + filter)

- SP-NB: 0.0001096 J to 0.0001362 J µg/L (W031 at RM 6.1W, February 2007)
- SP-NS: 0.0001085 J to 0.0001298 J µg/L (W031 at RM 6.1W, February 2007)
- T-NB: ND to 0.0001577 µg/L (W027 at Multnomah Channel , February 2007)
- T-NS: ND to 0.0001593 J µg/L (W005 at RM 3.9, March 2007)

- T-VI: 0.000051 to 0.000384 µg/L (W005 at RM 3.9, January 2006)

Storm Event XAD (combined column + filter)

- SP-NB: 0.00003617 J to 0.00005005 J µg/L (W031 at RM 6.1W, November 2006)
- SP-NS: 0.0000319 J to 0.0000498 J µg/L (W031 at RM 6.1, November 2006)
- T-NB: 0.0000306 J to 0.00004815 J µg/L (W024 at RM 16, November 2006)
- T-NS: 0.0000322 J to 0.00005367 J µg/L (W024 at RM 16, November 2006)
- T-VI: 0.0000251 J to 0.0000387 J µg/L (W023 at RM 11, November 2006)

5.4.11.3 ~~Dieldrin~~ Spatial Distribution of Dieldrin

Several of the surface water samples analyzed for dieldrin exceeded the human health NRWQC value developed to be protective of drinking water and consumption of organisms (0.000052 µg/L, based on carcinogenic risk of 10-6). Most of the exceedances were found in high flow XAD samples collected from January 2007 to March 2007, with no apparent pattern of higher concentrations linked to specific sampling locations. One low flow XAD sample (W015, RM 6.9W, November 2004) exceeded this human health threshold. Storm water-influenced flow results approached this human health criterion in several samples and exceeded the criterion in one sample collected in November 2006 (W024 at RM 16). One low flow XAD sample (W015 at RM 6.9W, November 2004) exceeded this human health threshold. No sample result exceeded the dieldrin chronic NRWQC for protection of aquatic life (0.056 µg/L).

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~~5.4.34.0 Aldrin in Surface Water~~

~~High-volume samples were analyzed for aldrin (reported in pg/L) by HRGC/HRMS. Peristaltic samples were also collected and analyzed for aldrin (reported in µg/L). Dissolved and particulate aldrin concentrations in surface water XAD column and filter samples are depicted in a histogram by flow event type in Figure 5.3-105. Peristaltic data are presented in Figure 5.3-106. The same data are plotted by channel position in Figures 5.3-107 and 5.3-108. Aldrin was detected in 69 percent of particulate (XAD filter) and 73 percent of dissolved (XAD column) samples and only 1 percent of the peristaltic samples during Round 2A and 3A sampling activities.~~

~~Total aldrin measured in single-point samples collected during low-flow conditions ranged from 0.31 J pg/L to 16.3 J pg/L at Station W015 (RM 6.9) in November 2004.~~

Concentrations in transect samples measured during low-flow conditions ranged from undetected to 6.62 J pg/L at Station W005 (RM 4) in September 2006.

Total aldrin was not detected in peristaltic samples during the Round 2A and 3A low-flow events.

Total aldrin measured in single-point samples collected during high-flow conditions in January 2007 ranged from undetected to 4.1 J pg/L at Station W033 (NB; RM 7) in January 2007. Concentrations measured in transect samples during high-flow conditions ranged from 1.2 J pg/L to 6.0 J pg/L at Station W025M (RM 2) in January 2007.

Total aldrin was detected in only one peristaltic sample (single-point) during high-flow conditions: 0.0052 µg/L at Station W030 (NB; RM 5.5) in January 2007.

Total aldrin measured in single-point samples collected during the November 2006 stormwater-influenced event ranged from undetected to 4.8 J pg/L at Station W033 (NS; RM 7). Concentrations measured in transect samples during this event ranged from undetected to 5.8 J pg/L at Station W027 (NB; RM 2.9).

Total aldrin was not detected in peristaltic samples during the stormwater-influenced event.

The aldrin dissolved concentrations were greater than the particulate values, with a major exception at RM 6.9 (W015). With several exceptions, total aldrin concentrations were fairly consistent within the flow conditions, with downstream samples typically somewhat higher than upstream samples.

5.4.43.0 Dieldrin in Surface Water

High-volume samples were analyzed for dieldrin (reported in pg/L) by HRGC/HRMS. Peristaltic samples were also collected and analyzed for dieldrin (reported in µg/L) by routine methodology (i.e., EPA 8081A). Dissolved and particulate dieldrin concentrations in surface water XAD column and filter samples are depicted in a histogram by flow event type in Figure 5.3-109. Peristaltic data are presented in Figure 5.3-110. The same data are plotted by channel position in Figures 5.3-111 and 5.3-112. Dieldrin was detected in all dissolved (XAD columns) and 70 percent of particulate (XAD filters) surface water samples and 3 percent of peristaltic samples collected during Round 2A and 3A sampling activities.

Total dieldrin measured in single-point XAD samples collected during low-flow conditions ranged from 22.7 to 62.5 pg/L at Station W015 (RM 6.9 in November 2004). Concentrations in transect samples measured during low-flow ranged from 16.7 J pg/L to 48.7 J pg/L at Station W005 (RM 4 in September 2006). Total dieldrin was not detected in peristaltic samples during the low-flow events.

~~Total dieldrin measured in single-point XAD samples collected during high-flow conditions in January 2007 ranged from 108 J pg/L to 190 pg/L at Station W033 (NB; RM 7). Concentrations measured in transect samples during high flow ranged from 70.5 J pg/L to 384 pg/L (Station W005 at RM 4 in January 2006).~~

~~Total dieldrin measured in single-point XAD samples collected during the November 2006 stormwater-influenced event ranged from 31.9 J pg/L to 50.1 J pg/L at Station W031 (NB; RM 6.1). Concentrations measured in transect samples during this event ranged from 25.1 J pg/L at Station W025W (RM 2) to 53.7 J pg/L at Station W024 (NS; RM 16).~~

~~Total dieldrin was detected in three single-point peristaltic samples during the high-flow sampling event at concentrations of 0.001 NJ µg/L at Station W029 (NB; RM 4.4), 0.0012 J µg/L at Station W028 (NB; RM 3.6), and 0.0012 NJ µg/L at Station W036 (NB; RM 8.6) in January 2007.~~

~~Total dieldrin was not detected in peristaltic samples during the stormwater-influenced event.~~

5.4.12 ~~The dieldrin dissolved concentrations were much greater than the particulate values (typically on the order of 90 percent of the total concentration). Total dieldrin concentrations had a small range in the low-flow and stormwater-influenced samples, and were higher with the high-flow event. The high-flow upstream concentrations were higher than all Study Area concentrations during the low-flow and stormwater-influenced events, whereas concentrations in the Study Area were comparable during the low-flow and stormwater-influenced events, making upstream to downstream patterns difficult to assess with the existing range of sampling events.~~ **Arsenic in Surface Water**

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Arsenic data are summarized in Tables 5.4-~~6~~5 through 5.4-11~~2~~0. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-~~8~~11, and 5.4-1~~0~~6. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and ~~through~~ 5.5-11a-d~~0~~ ~~(high flow events), Tables 5.4-12 through 5.4-15 (low-flow events), and Tables 5.4-17 through 5.4-20 (storm water-influenced events)~~. All total and dissolved arsenic surface water sample results are presented in Tables 5.4-21a-b~~30 and 5.4-31, respectively,~~ by sample event and sample ID number. Dissolved and particulate arsenic concentrations in surface water collected from peristaltic pumps are presented in stacked bar graphs by flow event on Figures 5.4-44~~a-c~~ and by river mile/channel position on Figure 5.4-45.

Arsenic concentrations at the transect locations as a function of flow rate are presented on Figure 5.4-46. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

Figure 5.4-476 presents a scatter plot of all arsenic surface water data. Note the symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow).

~~Arsenic concentrations at the transect locations as a function of flow rate are presented on Figure 5.4-47. The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.~~

5.4.12.1 Arsenic Data

Peristaltic samples were collected and analyzed by EPA Method 6020 for total and dissolved arsenic during Rounds 2A and 3A. Arsenic was detected in 78 percent of the 174 dissolved samples and 90 percent of 174 total samples during the Round 2A and 3A sampling events.

Total arsenic concentrations were generally consistent across the entire Study Area during the Round 2A and 3A sampling events. The overall range of detected concentrations for all total arsenic samples was narrow, ranging from 0.25 to 0.75 µg/L suggesting that there are no specific source areas for arsenic contamination.

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5.4.12.2 Arsenic Relationship to River Flow ~~Rate~~Conditions

Detected arsenic concentrations were relatively consistent regardless of flow rate; however, frequency of detection was significantly reduced during storm water-influenced events. The frequency of detection was 100% for total arsenic and 98% for dissolved arsenic for all combined low flow and high flow sampling event sample results. The frequency of detection was 58% for total arsenic and 13% for dissolved arsenic for the storm water-influenced samples.

While concentrations were relatively consistent, in general, ~~concentrations~~they were slightly higher in low flow sampling events with concentrations ranging from 0.33 to 0.75 µg/L compared to high flow sampling events with concentrations ranging from 0.25 to 0.63 µg/L. Thirty-nine storm water-influenced samples displayed a narrow range of detections between 0.43 to 0.53 µg/L. Dissolved and particulate arsenic concentrations in surface water are depicted in histograms by flow event type on Figure~~s~~ 5.4-44~~a-c~~ for high flow, low flow and storm water-influenced events.

Total arsenic measured in single-point samples collected during low flow conditions ranged from 0.33 µg/L to 0.75 µg/L at station W001 (RM 2.0E in July 2005). Dissolved arsenic measured in single-point samples collected during low flow conditions ranged from 0.25 µg/L to 0.64 µg/L at station W001 (RM 2.0E in July 2005). Total arsenic concentrations in transect samples measured during low flow events ranged from 0.35 to 0.64 µg/L (station W025 at RM 2.0E in September 2006). Dissolved arsenic concentrations in transect samples measured during low flow events ranged from 0.19 to 0.60 µg/L (station W025 at RM 2.0M in September 2006).

Total arsenic measured in single-point samples collected during high flow conditions in February 2007 ranged from 0.30 µg/L to 0.63 J µg/L at station W034 (NS; RM 7.5). Dissolved arsenic measured in single-point samples collected during high flow conditions ranged from 0.19 J µg/L to 0.63 J µg/L in February 2007 at station W037 (NB; RM 9.6W). Total arsenic concentrations measured in transect samples during high flow ranged from 0.25 to 0.54 µg/L at station W005 (RM 4) and station W023 (RM 6.3), in January 2006. Dissolved arsenic concentrations measured in transect samples during high flow ranged from 0.20 to 0.34 µg/L at station W034 (NS; RM 7.5W) in February 2007.

Total arsenic measured in single-point samples collected during the November 2006 storm water-influenced event ranged from 0.43 J µg/L to 0.53 J µg/L at station W038 (NB; RM 11). Dissolved arsenic measured in single-point samples ranged from 0.38 J µg/L to 0.48 µg/L at station W038 (NB; RM 11E). Total arsenic concentrations measured in transect samples during this event ranged from undetected to 0.48 J µg/L at station W005 (NB; RM 4). Dissolved arsenic concentrations measured in transect samples collected during this event ranged from undetected to 0.41 J µg/L at station W034 (NB; RM 7.5W).

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5.4.12.3 ~~Arsenic~~ Spatial Distribution of Arsenic

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All of the total and dissolved arsenic surface water results were less than the drinking water MCL of 10 µg/L and the chronic NRWQC of 150 µg/L for the protection of aquatic life. Conversely, all of the total and dissolved arsenic concentrations exceeded the human health NRWQC value of 0.018 µg/L developed to be protective of drinking water and consumption of organisms. All detected and undetected concentrations were at least an order of magnitude higher, with the minimum detected dissolved concentration of 0.18 µg/L and the lowest undetected reporting limit of 0.37 µg/L.

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~~5.4.51.0 Arsenic in Surface Water~~

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~~Peristaltic samples were collected and analyzed for arsenic during Round 2A and 3A. Dissolved and particulate arsenic concentrations in surface water are depicted in histograms by flow event type in Figure 5.3-113, and by channel position in Figure 5.3-114. Arsenic was detected in 78 percent of dissolved peristaltic samples and 90 percent of total peristaltic samples during the Round 2A and 3A sampling events.~~

~~Total arsenic measured in single-point samples collected during low-flow conditions ranged from 0.33 µg/L to 0.75 µg/L at Station W001 (RM 2) July 2005. Concentrations in transect samples measured during low-flow ranged from 0.35 to 0.64 µg/L (Station W025E at RM 2 in September 2006).~~

~~Total arsenic measured in single-point samples collected during high-flow conditions in January 2007 ranged from 0.3 µg/L to 0.63 J µg/L at Station W034 (NS; RM 7.5).~~

~~Concentrations measured in transect samples during high-flow ranged from 0.25 to 0.54 µg/L at Station W005 (RM 4) and Station W023 (RM 6.3), in January 2006.~~

~~Total arsenic measured in single-point samples collected during the November 2006 stormwater-influenced event ranged from 0.43 J µg/L to 0.53 J µg/L at Station W038 (NB; RM 9.9). Concentrations measured in transect samples during this event ranged from undetected to 0.48 J µg/L at Station W005 (NB; RM 4).~~

5.4.13 ~~Total arsenic concentrations were generally consistent across the entire Study Area during the Round 2A and 3A sampling events. Concentrations were generally higher in low-flow sampling events.~~ Chromium in Surface Water

Data for chromium in surface water are summarized in Tables 5.4-~~6~~5 through 5.4-11~~2~~0. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-~~8~~11, and 5.4-1~~0~~6. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and ~~through~~ 5.4-11a-d~~0 (high flow events), 5.4-12 through 5.4-15 (low flow events), and 5.4-17 through 5.4-20 (storm water-influenced events)~~. All total and dissolved chromium surface water sample results are presented in Tables 5.4-~~2~~32a-b ~~and 5.4-33, respectively,~~ by sample event and sample ID number.

Dissolved and particulate chromium concentrations in surface water collected from peristaltic pumps are presented in stacked bar graphs by flow event on Figures 5.4-48~~a-c~~ and by river mile/channel position on Figure 5.4-49. Figure 5.4-50 is a line plot of transect chromium concentrations in surface water by river mile (RM 2-16). The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event. ~~Figure 5.4-50 is a scatter plot of chromium concentrations in surface water by river mile (RM 2-16). The symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow).~~ Finally, Figure 5.4-51 is a scatter plot of chromium concentrations in surface water by river mile (RM 2-16). The symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow).~~Figure 5.4-51 is a line plot of transect chromium concentrations in surface water by river mile (RM 2-16). The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.~~

5.4.13.1 Chromium Data

Peristaltic samples were collected and analyzed by EPA Method 6020 for total and dissolved chromium during Rounds 2A and 3A. Chromium was detected in 34 percent of dissolved samples and 63 percent of total samples during the Round 2A and 3A sampling events.

Total chromium concentrations were generally consistent across the entire Study Area during the Round 2A and 3A sampling events. The overall range of detected

concentrations for all total chromium samples was 0.2 to 1.92 µg/L. The range of detected concentrations of dissolved chromium was narrower, ranging from 0.1 to 0.83 µg/L.

5.4.13.2 Chromium Relationship to River Flow ~~Rate~~Conditions

In general, chromium concentrations were slightly lower in samples collected during low flow sampling events with concentrations of total chromium ranging from 0.2 to 0.91 µg/L compared to results from high flow sampling events where total chromium concentrations ranged from 0.58 to 1.92 µg/L. Dissolved chromium concentrations were generally lower in low flow samples. Dissolved chromium concentrations ranged from 0.43 to 0.83 µg/L in high flow samples and from 0.1 to 0.33 µg/L in low flow samples.

Thirty-nine storm water-influenced samples were analyzed for total and dissolved chromium. Neither total chromium nor dissolved chromium was detected in any of those samples.

Total chromium measured in single-point samples collected during low flow conditions ranged from 0.2 µg/L to 0.91 µg/L at station W004 (RM 3.7E) in March 2005. Concentrations of total chromium in transect samples measured during low flow events ranged from 0.29 to 0.61 µg/L at station W023 (RM 11) in March 2005.

Dissolved chromium measured in single-point samples collected during low flow conditions ranged from 0.1 µg/L to 0.33 µg/L at station W004 (RM 3.7E) in March 2005. Concentrations of dissolved chromium in transect samples measured during low flow events ranged from 0.12 to 0.29 µg/L at station W011 (RM 6.3) in July 2005.

Total chromium measured in single-point samples collected during high flow conditions in February 2007 ranged from 0.7 µg/L to 1.7 J µg/L at station W036 (RM 8.6W). Concentrations of total chromium measured in transect samples during high flow ranged from 0.58 to 1.92 µg/L at station W031 (RM 6.1W) in February 2007.

Dissolved chromium was not detected in any single-point samples collected during high flow conditions. Dissolved chromium concentrations measured in transect samples during high flow conditions ranged from 0.43 to 0.83 µg/L at station W024 (RM 16) in January 2007.

Neither total nor dissolved chromium was detected in any single-point or transect samples collected during the November 2006 storm water-influenced sampling event.

5.4.13.3 ~~Chromium~~ Spatial Distribution of Chromium

All of the total and dissolved chromium surface water results were less than the drinking water MCL of 100 µg/L. A human health NRWQC developed to be protective of drinking water and consumption of organisms has not been established for chromium. The chronic NRWQC criterion for protection of aquatic life exposed to dissolved

trivalent chromium in surface water, based on a hardness of 25 mg/L CaCO3/L, is 23.8 µg/L. All dissolved chromium concentrations remain below this aquatic life criterion.

5.4.14 Copper in Surface Water

Copper data are summarized in Tables 5.4-65 through 5.4-1120. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-811, and 5.4-106. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.9a-d, and through 5.4-11a-d0 (high flow events), Tables 5.4-12 through 5.4-15 (low flow events), and Tables 5.4-17 through 5.4-20 (storm water-influenced events). All total and dissolved copper surface water sample results are presented in Tables 5.4-23a-b4 and 5.4-35, respectively, by sample event and sample ID number.

Dissolved and particulate copper concentrations in surface water collected from peristaltic pumps are presented in stacked bar graphs by flow event on Figures 5.4-52a-c and by river mile/channel position on Figure 5.4-53. Figure 5.4-54 is a line plot of transect copper concentrations in surface water by river mile (RM 2-16). The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event. Figure 5.4-54 is a scatter plot of copper concentrations in surface water by river mile (RM 2-16). The symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow). Finally, Figure 5.4-55 is a scatter plot of copper concentrations in surface water by river mile (RM 2-16). The symbols and colors indicate the sample type—point vs. transect—and the general flow conditions of the sampling event—low flow, storm water-influenced, or high flow). Figure 5.4-55 is a line plot of transect copper concentrations in surface water by river mile (RM 2-16). The data points presented in this figure are averages of all data points collected at a particular transect for each measured flow event.

5.4.14.1 Copper Data

Peristaltic samples were collected and analyzed by EPA Method 6020 for total and dissolved copper during Rounds 2A and 3A. Copper was detected in 99 percent of 174 dissolved samples and 100 percent of 174 total samples during the Round 2A and 3A sampling events.

Total copper concentrations were generally consistent across the entire Study Area during the Round 2A and 3A sampling events. The overall range of detected concentrations for all total copper samples ranged from 0.65 to 3.61 µg/L suggesting that there are no specific source areas for copper contamination.

5.4.14.2 Copper Relationship to River Flow RateConditions

Total copper concentrations were generally consistent across the entire Study Area during the Round 2A and 3A sampling events. Concentrations were generally higher in samples collected during the high flow sampling events, with concentrations ranging from 1.1 to 3.6 µg/L compared to samples collected during low flow sampling events,

with concentrations ranging from 0.68 to 2.09 µg/L. Thirty-nine storm water-influenced samples displayed a narrow range of detections between 0.65 to 1.14 µg/L. Dissolved and particulate copper concentrations in surface water are depicted in histograms by flow event type on Figures 5.4-52~~a-c~~ for high flow, low flow and storm water-influenced events.

Total copper measured in single-point samples collected during low flow conditions ranged from 0.68 µg/L to 2.09 µg/L at station W004 (RM 3.7) in March 2005. Dissolved copper measured in single-point samples collected during low flow conditions ranged from undetected to 1.64 µg/L at station W022 (NB; RM 9.7W) in July 2005. Total copper concentrations in transect samples measured during low flow events ranged from 0.68 µg/L to 1.55 µg/L at station W005 (NB; RM 3.9) in September 2006. Dissolved copper concentrations in transect samples measured during low flow events ranged from 0.45 µg/L to 0.83 J µg/L at station W011 (RM 6.3) in July 2005.

Total copper measured in single-point samples collected during high flow conditions ranged from 1.63 µg/L to 2.72 µg/L at station W036 (NS; RM 8.6) in January 2006. Dissolved copper measured in single-point samples collected during high flow conditions ranged from 0.55 µg/L to 0.73 µg/L at station W037 (NB; RM 9.6W) in February 2007. Total copper concentrations measured in transect samples during high flow events ranged from 1.1 µg/L to 3.61 J µg/L at station W023 (RM 11) in January 2006. Dissolved copper concentrations measured in transect samples during high flow events ranged from 0.43 µg/L to 1.58 J µg/L at station W023 (RM 11) in January 2006.

Total copper measured in single-point samples collected during the November 2006 storm water-influenced event ranged from 0.84 to 0.96 µg/L at station W036 (NB; RM 8.6). Dissolved copper measured in single-point samples collected during this event ranged from 0.50 to 0.64 µg/L at station W028 (NS; RM 3.6E). Total copper concentrations measured in transect samples during this event ranged from 0.65 µg/L to 1.14 µg/L at station W035 (NS; RM 8.5). Dissolved copper concentrations measured in transect samples during this event ranged from 0.46 µg/L to 1.23 µg/L at station W023 (RM 11M).

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5.4.14.3 ~~Copper~~ Spatial Distribution of Copper

All of the total and dissolved copper surface water results were less than the drinking water MCL of 1,300 µg/L and the human health NRWQC value of 1,300 µg/L developed to be protective of drinking water and consumption of organisms. There are no NRWQC available for the protection of aquatic life. The site-specific TRV for this hardness-dependent metal developed in the BERA is 2.74 µg/L. There were five exceedances of the TRV. The results from three samples collected in January 2006 were greater than the TRV at the following stations during high flow conditions:

- W005 (RM 3.9),
- W023 (RM 11), and

- W024 (RM 16).

In addition, results from two samples collected during high flow conditions in January 2007 also exceeded the TRV at the following locations:

- W027 (Multnomah Channel), and
- W031 (6.1 W)

These results do not suggest potential source areas for copper.

~~5.4.55.1 Copper in Surface Water~~

~~Peristaltic samples were collected and analyzed for copper during Round 2A and 3A. Dissolved and particulate copper concentrations in surface water are depicted in histograms by flow event type in Figure 5.3-115, and by channel position in Figure 5.3-116. Copper was detected in 99 percent of dissolved and 100 percent of total copper samples during Round 2A and 3A sampling events.~~

~~Total copper measured in single-point samples collected during low-flow conditions ranged from 0.68 µg/L to 2.09 µg/L at Station W004 (RM 3.7) in March 2005. Concentrations in transect samples measured during low-flow ranged from 0.68 µg/L to 1.55 µg/L at Station W005 (NB; RM 4) in September 2006.~~

~~Total copper measured in single-point samples collected during high-flow conditions in January 2007 ranged from 1.47 µg/L to 3.49 µg/L at Station W031 (NB; RM 6.1). Concentrations measured in transect samples during high-flow ranged from 1.1 µg/L to 3.68 J µg/L at Station W023 (RM 11) in January 2006.~~

~~Total copper measured in single-point samples collected during the November 2006 stormwater-influenced event ranged from 0.79 to 1.14 µg/L at Station W035 (NS; RM 8.5). Concentrations measured in transect samples during this event ranged from 0.65 µg/L to 1.1 µg/L at Station W024 (NS; RM 16).~~

~~Total copper concentrations were generally consistent across the entire Study Area during the Round 2A and 3A sampling events. Concentrations were generally higher in the high-flow sampling events.~~

5.4.15 Zinc in Surface Water

Data for zinc in surface water are summarized in Tables 5.4-~~6~~5 through 5.4-11~~2~~0. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-~~8~~11, and 5.4-1~~0~~6. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and ~~through~~ 5.4-11a-d~~0 (high flow events), Tables 5.4-12 through 5.4-15 (low flow events), and 5.4-17 through 5.4-20 (storm water-influenced events)~~. All total and dissolved zinc surface water sample results are presented in Tables 5.4-24a-b~~36 and 5.4-37, respectively,~~ by sample event and sample ID number.

Dissolved and particulate zinc concentrations in surface water collected from peristaltic pumps are presented in stacked bar graphs by flow event on Figures 5.4-56~~a-c~~ and by river mile/channel position on Figures 5.4-57~~a-b~~. Figure 5.4-58 is a line plot of transect zinc concentrations in surface water by river mile (RM 2-16). ~~Figure 5.4-58 is a scatter plot of zinc concentrations in surface water by river mile (RM 2-16).~~ Finally, Figure 5.4-59 is a scatter plot of zinc concentrations in surface water by river mile (RM 2-16). ~~Figure 5.4-59 is a line plot of transect zinc concentrations in surface water by river mile (RM 2-16).~~

5.4.15.1 Zinc Data

Peristaltic samples were collected and analyzed by EPA Method 6020 for total and dissolved zinc during Rounds 2A and 3A. Zinc was detected in 43 percent of dissolved samples and 76 percent of total samples during the Round 2A and 3A sampling events.

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Total zinc concentrations in all surface water samples during the Round 2A and 3A sampling events ranged from 2.1 to 57.9 µg/L. The range of detected concentrations of dissolved zinc in all Round 2A and 3A samples was 0.9 to 41.9 µg/L.

5.4.15.2 Zinc Relationship to River Flow ~~Rate~~Conditions

With the exception of one total result (57.9 µg/L) and one dissolved result (41.9 µg/L), detected zinc concentrations were within a narrow range regardless of flow. With the exclusion of the one total result, detected concentrations of total zinc in low flow samples ranged from 1.65 to 8.8 µg/L at station W004 (RM 3.7E) in March 2005. Total zinc concentrations ranged from 1.85 to 8.4 µg/L during high flow sampling events. Dissolved zinc concentrations were generally lower in low flow samples. With the exception of one dissolved result, dissolved zinc concentrations ranged from nondetect to 4.9 µg/L at station W018 (RM 8.3) in November 2004 in low flow samples. Dissolved zinc was only detected in one high flow sample at 2.5 µg/L.

Thirty-nine storm water-influenced samples were analyzed for total and dissolved zinc. Total zinc was not detected in any of the samples, while dissolved zinc was detected in five of 39 samples (4.8 to 6.6 µg/L).

With the inclusion of all samples, total zinc measured in single-point samples collected during low flow conditions ranged from 1.65 µg/L to 57.9 µg/L at station W022 (RM 9.7W) in November 2004. Concentrations of total zinc in transect samples measured during low flow events ranged from 2.1 to 6.1 µg/L at station W023 (RM 11W) in September 2006.

With the inclusion of all samples, dissolved zinc measured in single-point samples collected during low flow conditions ranged from 0.9 µg/L to 41.9 µg/L at station W022 (RM 9.7W) in November 2004. Concentrations of dissolved zinc in transect

samples measured during low flow events ranged from 1.4 to 2.2 µg/L at station W023 (RM 11) in November 2004.

Total zinc measured in single-point samples collected during high flow conditions in February 2007 ranged from 3 to 8.4 µg/L at station W031 (RM 6.1W). Concentrations of total zinc measured in transect samples during high flow conditions ranged from 1.85 to 6.38 µg/L at station W024 (RM 16) in January 2006.

Dissolved zinc was not detected in any single-point samples collected during high flow conditions. Dissolved zinc was detected in only one transect sample collected during high flow conditions; ~~–~~2.5 µg/L at station W005 (RM 3.9) in January 2006.

Total zinc was not detected in any storm water-influenced sample. Detected concentrations of dissolved zinc in single-point storm water-influenced samples ranged from 4.8 to 6.6 µg/L at station W034 (RM 7.5W) in November 2006. Dissolved zinc was detected in a single transect storm water-influenced sample at 5.1 µg/L at station W025M (RM 2M) in November 2006.

~~5.4.55.2~~5.4.15.3 ~~Zinc~~ Spatial Distribution of Zinc

All of the total and dissolved concentrations of zinc in surface water were substantially below the human health NRWQC value of 7,400 µg/L developed to be protective of drinking water and consumption of organisms. An MCL has not been established for zinc. The chronic NRWQC criterion for protection of aquatic life exposed to dissolved zinc in surface water, based on a hardness of 25 mg/L $CaCO_3$/L, is 36.5 µg/L. Nearly all dissolved zinc concentrations remained below this aquatic life criterion. The single exceedance (41.9 µg/L) of this chronic criterion was measured at station W022 (RM 9.7W), in a single-point low flow sample collected November 2004.

~~**Zinc in Surface Water**~~

~~Peristaltic samples were collected and analyzed for zinc during Round 2A and 3A. Dissolved and particulate zinc concentrations in surface water are depicted in histograms by flow event type in Figures 5.3-117 and 5.3-118, and by channel position in Figures 5.3-119 and 5.3-120. Zinc was detected in 42 percent of dissolved peristaltic samples and 76 percent of total peristaltic samples collected during Round 2A and 3A sampling events.~~

~~Total zinc measured in single-point samples collected during low-flow conditions ranged from 1.7 µg/L to 57.9 µg/L; the highest concentration was found at Station W022 (RM 9.7) in November 2004. Concentrations in transect samples measured during low-flow ranged from 2.1 µg/L to 6.1 µg/L; the highest concentration was found at Station W023W (RM 16) in September 2006.~~

~~Total zinc measured in single-point samples collected during high-flow conditions ranged from 3.0 µg/L to 8.4 µg/L; the maximum concentration was found at Station~~

~~W031 (NB; RM 6.1) in January 2007. Concentrations measured in transect samples during high-flow ranged from 1.9 µg/L to 6.4 µg/L; maximum concentrations were found at Station W023 (RM 11) and Station W024 (RM 16) in January 2006.~~

~~Zinc in samples collected during stormwater-influenced conditions was found in the dissolved fraction only. Single-point concentrations ranged from 4.8 µg/L to 6.6 µg/L; the maximum concentration was found at Station W034 (NS; RM 7.5) in November 2006. Zinc was detected in only one transect sample (5.1 µg/L) at Station W025M (RM 2) in November 2006.~~

~~The concentrations of total zinc were generally consistent throughout the Study Area during the Round 2A and 3A sampling events.~~

5.4.16 TBT Ion in Surface Water

Data for TBT in surface water are summarized in Tables 5.4-6~~5~~ through 5.4-211~~0~~. Transect samples are summarized by flow event in Tables 5.4-6, 5.4-8~~11~~, and 5.4-10~~6~~. Single-point samples are summarized by flow event in Tables 5.4-7a-d, 5.4-9a-d, and ~~through~~ 5.4-11a-d~~0 (high flow events), Tables 5.4-12 through 5.4-15 (low flow events), and Tables 5.4-17 through 5.4-20 (storm water-influenced events)~~. All TBT surface water data are presented in Table 5.4-25~~38~~ by sample event and sample ID number.

TBT concentrations in surface water collected from peristaltic pumps are presented in stacked bar graphs by flow event and by river mile/channel position on Figures 5.4-60~~a-c~~ and Figure 5.4-61, respectively. Figure 5.4-62 is a line plot of transect TBT concentrations in surface water by river mile (RM 2-16). ~~Figure 5.4-62 is a scatter plot of TBT concentrations in surface water by river mile (RM 2-16).~~ Finally, Figure 5.4-63 is a scatter plot of TBT concentrations in surface water by river mile (RM 2-16). ~~Figure 5.4-63 is a line plot of transect TBT concentrations in surface water by river mile (RM 2-16).~~

5.4.16.1 TBT Data

Peristaltic samples of surface water were collected and analyzed by the Krone Method XXXX for TBT during Rounds 2A and 3A. TBT was detected in a small number of samples, about 7 percent of all surface water samples collected during the Round 2A and 3A sampling events. Detected TBT concentrations in all surface water samples collected during the Round 2A and 3A sampling events ranged from 0.0006 to 0.011 µg/L.

5.4.16.2 TBT Relationship to River Flow ~~Rate~~Conditions

The small number of TBT detections in surface water samples was associated with a narrow range of detected concentrations regardless of flow. Detected concentrations of TBT in low flow samples ranged from 0.00095 to 0.0012 µg/L compared to high flow sampling events where TBT concentrations ranged from 0.0021 to 0.0035 µg/L.

Thirty-seven storm water-influenced samples were analyzed for TBT. TBT was detected in only four of these samples at concentrations ranging from 0.0010 to 0.0013 µg/L.

TBT measured in single-point samples collected during low flow conditions ranged from 0.00095 µg/L to 0.0023 µg/L at station W004 (RM 3.7E) in March 2005. TBT was not detected in any transect samples measured during low flow sampling events.

TBT was not detected in any single-point samples collected during high flow conditions. Concentrations of TBT measured in transect samples during high flow ranged from 0.0021 to 0.0035 µg/L at station W035 (RM 8.5) in February 2007.

TBT was not detected in any single-point storm water-influenced sample. Detected concentrations of TBT in transect samples that were storm water-influenced ranged from 0.0001 to 0.011 µg/L at W024 (RM 16) in November 2006.

5.4.16.3 ~~TBT~~ Spatial Distribution of TBT

All of the detected concentrations of TBT measured in surface water remained below all applicable criteria, including the EPA RSL for tapwater for protection of human health (0.47 µg/L, based on HQ=0.1) and the chronic NRWQC value for protection of aquatic life (0.072 µ g/L).

5.4.17 Site-Specific Evaluation of Hydrophobic Contaminants

For the purposes of this evaluation and presentation, hydrophobic contaminants are defined as those contaminants or groups of contaminants that are insoluble or minimally soluble in water, and are therefore expected to bind strongly to sediments and suspended particulates and to be present in dissolved form in water at low concentrations. Hydrophobic contaminants included in this evaluation are PCBs, dioxins and furans, DDT and related compounds (DDx), and PAHs.

~~Summary of Nature and Extent of Indicator Chemicals in Surface Water~~

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~~The four ICs selected for discussion for surface water exhibited distinct maxima at one or more of the Study Area locations. This discussion includes concentrations of bounding ICs that are notably high relative to other locations in the surface water data set. Trends relative to flow conditions are also discussed.~~

~~Upstream between RM 11 and 16, there were elevated PCB and PCDD/F concentrations (compared to other concentrations in this reach) at RM 11. Two of the three highest PCB concentrations and the second highest PCDD/F concentration at RM 11 were measured on the east side of the river, suggesting the existence of localized sources in this area. For DDx, the high-flow concentrations at RM 11 and 16 were much greater than the low-flow and stormwater-influenced samples, indicating an upstream source or sources of DDx mobilized during high-flow conditions. PAH~~

~~concentrations between RM 11 and 16 tended to be lower than those within the Study Area.~~

~~There is a trend of decreasing PCB concentrations with increasing flow rates. Five of the six highest PCB concentrations were associated with low-flow sampling events, and concentrations were consistently lower in high-flow samples as compared to the two other flow regimes. Excluding the samples at RM 6.7, the, stormwater-influenced samples appear to be lower than the low-flow samples. High-flow conditions may overwhelm the local effects and control PCB concentrations in the Study Area until flow rates subside.~~

~~PCDD/F concentrations don't appear to be as dependent upon flow rate as PCBs. At the downstream end of the Study Area, the low-flow sample concentration ranges for both total PCBs and total PCDD/Fs decreased relative to ranges observed within the Study Area.~~

~~Within the Study Area, the highest concentrations of PCBs (highest including six of seven) and PCDD/Fs (highest) were found in Willamette Cove (RM 6.7) during low-flow conditions, which suggests a localized source or sources of these ICs in this vicinity.~~

~~Total DDx concentrations in surface water across the Study Area were dominated by five high-concentration samples (3,000 pg/L to 10,000 pg/L) collected at RM 6.9 and 7.2, adjacent to known pesticide sources to the river. The highest PAH concentrations (100,000 J pg/L to 230,000 J pg/L) were found at RM 6.9, as well as RM 7.2 and 8.5, adjacent to known PAH sources in the Study Area.~~

~~The highest total DDx (RM 6.9 and 7.2) and total PAH (three out of the five highest; RM 6.9) concentrations were measured in single-point samples during low-flow conditions. With the exception of these high-concentration samples, the range of PAH concentrations were fairly consistent across the Study Area. However, total DDx concentrations were elevated in high-flow samples from RM 11 and 16, as compared to the two other flow regimes, indicating an upstream source or sources of total DDx that becomes mobilized during high-flow conditions.~~

~~At the downstream end of the Study Area, total PCDD/Fs, DDx, and PAHs had consistently low concentrations with less variability among sampling event types than seen in Study Area samples. In contrast, total PCB congener concentrations in the downstream end of the Study Area were approximately 900 to 1,300 pg/L in single-point samples near RM 2 for the stormwater-influenced event, and total PCB congener concentrations downstream were higher than the upstream (RM 16) concentrations for all event types (low-flow, high-flow, stormwater-influenced).~~

5.4.17.1 Distribution Bbetween PCB Dissolved and Particulate Fractions

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The following subsections describe observed trending of dissolved ~~(XAD column)~~ and particulate ~~(XAD filter)~~ fractions by river mile, event type, and sample type of total PCB congener concentrations (PCBs) in the complete Round 2A and 3A data set. The spatial distribution of dissolved and particulate PCB concentrations and relationships to flow rate, TSS, and f_{oc} are described. PCB congeners were detected in all XAD filter and column samples collected during Round 2A and 3A sampling events.

5.4.17.1.1 PCB Particulate and Dissolved Concentrations

~~Figures 5.4-64a-b present a scatter plot of total PCB dissolved and particulate concentration pairs. Linear regression lines are shown for the high-flow, low-flow, and storm water-influenced sets of transect and point data.~~ Total PCB concentrations as a function of flow rate are presented in Figure 5.3-64.~~The PCB concentrations of the particulate (filter) and dissolved (column) fractions of each sample are shown on histogram Figures 5.4-65a-b and 5.4-66a-b.~~ Figures 5.3-65 and 5.3-66 show the dissolved and particulate fractions of total PCBs plotted against flow rate. All of the particulate and dissolved samples with concentrations >1,000 pg/L were collected during low-flow conditions, with the exception of a single dissolved sample collected during the stormwater-influenced sampling event. For the particulate fraction, low-flow samples cover a greater concentration range as compared to the high-flow and stormwater-influenced samples. For the dissolved fraction of total PCBs, low-flow and stormwater-influenced samples cover similar concentration ranges, while high-flow exhibit generally lower concentrations.

~~As seen on the scatter plots, samples with concentrations less than 0.0005 µg/L particulate and less than 0.0005 µg/L dissolved showed a fairly consistent trend in particulate/dissolved ratios, whereas the particulate/dissolved ratio varies substantially for high-concentration samples. In particular, l~~Low flow point samples collected at the upper end of the dissolved concentration range (>0.0005 µg/L) ~~had~~tended to have a higher particulate component of the total concentration. ~~Storm water-influenced point samples collected at the upper end of the dissolved concentration range had the lowest particulate component.~~

The high flow samples (both point and transect) tend to ~~show~~exhibit lower dissolved concentrations ~~for the given particulate concentration, or conversely, higher particulate concentrations for the given dissolved concentrations,~~ relative to the storm water-influenced flow and low flow samples. This suggests a different character/source of PCB contaminated sediment and/or suspended solids concentration and character during high flow events. ~~The following section further investigates differences in the suspended solids concentration and character.~~

The transect sample collected at RM 11 during the low flow event in November 2004 exhibited a high particulate to dissolved ratio. As noted previously, during collection of

this sample, the field crews observed runoff from a nearby storm drain, which may have contributed to this result.

~~The associations of PCBs with suspended solids and apparent partitioning were evaluated from the surface water data set.~~ Total PCB concentrations as a function of TSS are presented on Figures 5.4-67~~a-b~~. High flow samples (single-point and transect) exhibited the widest range and highest concentrations of TSS but the lowest PCB concentrations. Conversely, the remaining samples exhibited a ~~wide~~greater range in concentration over a small range in TSS. The high flow samples also exhibited a lower dissolved/particulate concentration ratio relative to the storm water-influenced and low flow samples.

Particulate total PCB concentrations and POC ~~(TOC–DOC)~~ concentrations are compared on Figures 5.4-68a-b. The high flow samples (single-point and transect) exhibited relatively low PCB concentrations for the corresponding POC ~~associated with the solids~~. The low POC values are consistent with the lower f_{oc} associated with TSS observed in high flow samples, as shown on Figure 5.4-69. This observation may suggest the introduction of suspended particles with low organic carbon content during high flow events. Further, the solids that become suspended in the water column during high flow events may have a different character (low f_{oc} and low PCB concentrations) than those introduced during low flow or storm water-influenced events. ~~The single-point samples characterized by high concentrations of PCBs (RM 5.5, 6.9, 8.3, and 11) did not have corresponding high TSS concentrations from the same events (Figures 5.4-67a-b). However, these samples did exhibit high particulate-phase PCB concentrations as a function of POC (Figures 5.4-68a-b), reflecting a higher f_{oc}.~~

Total PCB congener concentrations measured in the single-point samples during high flow conditions ranged from 0.000111 J µg/L to 0.000749 J µg/L at Station W035 (RM 8.5) in January 2007. Concentrations measured in transect samples during high flow ranged from 0.0000419 J µg/L to 0.000391 J µg/L at station W005 (RM 4) in January 2007.

A single storm water-influenced flow event was observed and sampled in November 2006. Total PCB congener concentrations measured in single-point samples during this storm water-influenced event ranged from 0.000112 J µg/L to 0.00259 J µg/L at Station W030 (RM 5.5). Concentrations measured in transect samples ranged from 0.000121 J µg/L to 0.00129 J µg/L at station W025E (RM 2).

5.4.17.2 Distribution ~~b~~Between PCDD/F Dissolved and Particulate Fractions

The following subsections describe the observed trending of dissolved and particulate fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS. This analysis was specific to total PCDD/Fs and ,therefore, does not extend to individual dioxins and furans. ~~However, Section 5.3.7.4 provides a discussion of PCDD/F composition and~~

patterns, which may assist with the identification of observed concentrations in the Study Area.

5.4.17.2.1 PCDD/F Dissolved and Particulate Concentrations

The dissolved (XAD column) and particulate (XAD filter) fractions of total PCDD/F concentrations for each surface water sample are presented as histograms by flow event type on Figure 5.43-4571140 and by channel position on Figure 5.43-46715. These figures clearly demonstrate that PCDD/Fs tend to partition to the particulate fraction in surface water within the Study Area. The extent of this tendency is presented oin Figure 5.43-5072a, which shows a scatter plot of the dissolved vs. particulate concentrations of total PCDD/Fs. The two highest concentrations measured at RM 6.7 and 11 during low -flow and storm water-influenced conditions, respectively, exhibit extremely higha particulate to dissolved ratios (greater than an order of magnitude difference between the two phases). If these samples are excluded from the analysis, as presented oin Figure 5.43-5172b, where the x-axis (particulate concentration) is zoomed, the tendency for partitioning into the solid phase is also apparent for low -flow and high -flow samples. However, the storm water-influenced sample concentrations appear to be more evenly distributed within the data set.

5.4.17.2.2 PCDD/F Associations with Suspended Solids

The associations of total PCDD/Fs with suspended solids and apparent partitioning were evaluated from the surface water data set. Total concentrations as a function of TSS are presented oin Figures 5.34-526973a-b and 5.3-53. PCDD/F concentrations in high flow transect samples exhibited aincreased slightly increasing trend with higher suspended solids for high -flow transect samples. However, concentrations appear to increase more rapidly with increased suspended solids for the high -flow single -point samples. TheConcentrations in storm water-influenced samples appear to increased independently of suspended solids in surface water. The transect and single -point samples collected during this event were all characterized by TSS values less than 10 mg/L. ThePCDD/F concentrations in low -flow transect samples appear to have a non-linear distribution with varying TSS and PCDD/F concentrations and, therefore, do not exhibit a clear trend in relation to TSS (Figures 5.34-527033a-b and 5.3-53).

Particulate total PCDD/F concentrations and POC concentrations are compared oin Figures 5.43-7054 and 5.3-55. As with PCBs, thePOC was relatively low in high -flow samples (single -point and transect) while exhibited relatively low PCDD/F concentrations for the corresponding POC associated with the solids. Conversely, the storm water-influenced samples tended to exhibit higher POC. The relationship of values in relation to total PCDD/F concentrations to TSS are presented on Figures 5.4-XX. Total PCDD/F concentrations in stormwater influenced flow samples and were associated with lower TSS (less than 10 mg/L) values. This may indicate that solids that become suspended during storm water-influenced events may have a unique character of high f_{oc} and varying loads of PCDD/Fs. Samples characterized by higher concentrations of PCDD/Fs did not have corresponding high TSS concentrations

~~compared to other samples from the same events (Figures 5.34-52~~73a-b ~~and 5.3-53).~~ However, these samples did exhibit a high particulate-phase PCDD/F concentration as a function of POC.

5.4.17.3 Distribution Between DDx Dissolved and Particulate Fractions

The following subsections describe the observed trending of total DDx dissolved and particulate fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS.

5.4.17.3.1 DDx Particulate and Dissolved Concentrations

The distribution of total DDx ~~(i.e., the sum of the dissolved and particulate concentrations)~~ by river mile is presented on histograms by flow event type on Figures 5.4-20~~75a-b~~ and histograms by channel position on Figures 5.4-21~~76a-b~~. ~~Although these figures show distinctly high total DDx concentrations at RM 6.9 and 7.2, there does not appear to be any clear patterns in the ratio of dissolved and particulate fractions or the distribution between single-point and transect samples.~~

~~The dissolved and particulate fractions of total DDx are plotted on scatter plots on Figures 5.4-77a-b. Linear regression lines are shown for the high flow, low flow, and storm water-influenced sets of transect and point data. The single-point and transect samples collected during the high flow events followed the general trend of the other flow types. The samples characterized by the highest dissolved concentration tended to have a higher particulate concentration.~~

Three samples collected at RM 2 (station W025) during high-flow conditions exhibited ~~had~~ higher dissolved to particulate ratios. This may be due to the lower suspended solids load in the downstream portion of the Study Area (at RM 2) rather than an actual shift in partitioning behavior.

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Total DDx concentrations as a function of flow rate are presented in Figures 5.4-71a-b. With the exception of the highest total DDx concentrations that were measured at RM 6.9 and 7.2, a clear relationship between flow rate and total DDx concentrations is not evident during low-flow conditions (Figure 5.3-71a). This may suggest the potential for localized sources within the mid-Study Area vicinity, especially near RM 6.9 and 7.2. ~~There does not appear to be a clear distinction between low flow and storm water-influenced or single-point and transect samples on these figures.~~

5.4.17.3.2 DDx Associations with Suspended Solids

~~The associations of total DDx with suspended solids and apparent partitioning were evaluated from the surface water data set.~~ Total concentrations as a function of TSS are presented on Figures 5.4-72~~8~~a-b. The highest ratios of DDx to TSS were exhibited in ~~concentration,~~ low flow samples ~~exhibited the highest ratios of total DDx to TSS. The single-point and transect~~while high flow samples exhibited a much lower ratio of total DDx concentration to TSS. The low flow and storm water-influenced samples had low suspended solids loads (25 J mg/L or lower) compared to high flow samples (up to 62 mg/L).

Particulate total DDx concentrations and POC concentrations are compared on Figures 5.4-739a-b. ~~The high flow transect and single-point samples tended to exhibit higher total particulate DDx concentrations and lower POC concentrations in the water column.~~ With the exception of low-flow point samples, DDx concentrations appear independent of POC. ~~As shown on Figure 5.4-69, h~~High flow samples exhibited higher TSS concentrations and lower f_{oc} on TSS percentages. Therefore, the higher concentrations in the surface water during high flow events (Figures 5.4-7280a-b) were present in spite of lower POC in the water column. Again, this may suggest a different source or sources of particles, possibly upstream of the Study Area, given the high inflow concentrations at RM 16 and 11 during high flow events. Higher POC concentrations were found in transect and single-point storm water-influenced and low flow samples with lower total particulate DDx concentrations.

5.4.17.4 Distribution Between PAH Dissolved and Particulate Fractions

The following subsections describe the observed trending of the dissolved and total fractions by river mile, event type, sample type, TSS, and f_{oc} of the TSS.

5.4.17.4.1 PAH Particulate and Dissolved Concentrations

The spatial distribution of dissolved and particulate total PAH concentrations is presented on histograms for each surface water sample by flow event type and river mile on Figure 5.4-81a; Figure 5.4-81b presents the same data with a reduced y-axis scale to better show lower concentrations. Figures 5.4-82a-b through 5.4-83a-b present the same data arranged by channel position. ~~The majority~~

Total PAH concentrations as a function of flow rate are presented in Figure 5.4-75. Four of the five highest concentrations of total PAHs were measured in single-point samples collected during low-flow conditions. Total PAH concentrations tended to vary within a flow condition rather than over the range of flow conditions sampled, although elevated PAHs were evident in low-flow samples from RM 7 to 2 compared to the high-flow and stormwater-influenced sampling events. Downstream near RM 2, the low-flow sample concentration ranges decreased relative to ranges observed further upstream within the Study Area.

While a general trend of greater partitioning in the dissolved phased is evident, ~~of total PAH concentrations were found in the dissolved rather than the particulate phase. However, there was one~~ notable exception ~~to this trend:~~was observed at ~~-~~station W035 at RM 8.5 ~~collected~~ during the January 2007 high flow event. Both the NB and NS samples ~~collected in January 2007~~ exhibited a much greater particulate to dissolved ratio. Also, at stations W011 (RM 6.3) and W005 (RM 4) the NB samples had noticeably higher particulate total PAH concentrations in the low flow and storm water-influenced sampling events. In the January 2007 high flow sampling event, this pattern was reversed at station W035 (RM 8.5), and the NS sample had the highest particulate total PAH concentration.

~~The dominance of the dissolved fraction is also illustrated in scatter plots of particulate and dissolved data on Figures 5.4-84a-b. Linear regression lines are shown for the high flow, low flow, and storm water-influenced sets of transect and point data. The apparently unique ratio at RM 8.5 is well illustrated on these figures (data points in the lower right quadrant) and does not appear to apply to other high flow samples. The unique ratio may suggest a different character/source of PAHs and/or suspended solids concentration and character for this sample location.~~

5.4.17.4.2 PAH Associations with Suspended Solids

Total PAH concentrations as a function of TSS are presented on Figures 5.4-76~~85a-b~~. High flow samples (single-point and transect) exhibited the widest range and highest concentrations of TSS but generally lower total PAH concentrations~~ compared to the majority of the data set~~. However, there does appear to be a trend of gradually increasing total PAH concentrations with higher TSS values ~~(somewhat linear)~~ for the high flow samples. ~~Otherwise, the l~~Low flow and storm water-influenced samples tended to ~~cluster together~~ exhibit~~ing~~ low TSS but ~~varying~~a wider range of PAH concentrations. ~~The storm water influenced (single-point and transect) and low flow single-point samples tended to exhibit this pattern most prevalently, with TSS values below 12 mg/L.~~

~~Samples collected from RM 8.5 during high flow in January 2007 did not adhere to the pattern of other samples collected during this particular flow regime as they exhibited high concentrations of total PAHs relative to TSS (Figures 5.4-85a-b). Although total PAHs measured in these samples were high relative to TSS, the particulate concentrations were much greater than the dissolved fractions (Figures 5.4-81a-b and 5.4-84a-b).~~

Particulate total PAH concentrations and POC concentrations are compared on Figure 5.4-77~~86~~. The high flow samples (single-point and transect) exhibited relatively low total PAH concentrations and POC. The low POC values are consistent with the lower observed f_{oc} of the suspended solids during this flow condition~~ (Figure 5.4-69)~~. Several high flow samples ~~(e.g., the sample with the highest particulate total PAH concentration at station W035, NS)~~ exhibited POC values equal to zero (Figure 5.4-77~~86~~)~~. The explanation for this is that~~ because the calculated POC was ~~set to equal~~considered to be zero if the DOC was greater than the TOC. This scenario provides further confirmation that the high flow events are characterized by suspended solids with low f_{oc}.

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